An Extensive Power System in the South

The Development of the Southern Power Company in the Carolinas Four Hundred Miles of Lines Operated at 44,000 to 100,000 Volts

BY CECIL P. POOLE

The Development Stage

Until within the last two or three years the hydroelectrical developments in the South were mostly local in scope, furnishing power to a few cotton mills in the immediate neighborhood of the power plant, or at the end of a comparatively short transmission line. This was due in part to the attitude of the mill men who, although the reliability, convenience and economy of the electric drive had been demonstrated in several instances, still looked upon it with distrust, and in part to the mistaken idea that power could be produced with a local steam plant cheaper than purchased from a hydroelectric company. But their feelings in this respect have recently undergone a change, a fact which capitalists were not slow to note, and the indications at present are that the next ten years will produce networks of systems extending over hundreds of square miles, and rivaling in amount of power transmitted any of the great Northern or Western systems.

It may be asked here where is the market for so much power, to which the reply is that in cotton mills alone nearly 13,000,000 spindles, using approximately 400,000 horsepower, are in operation in the South today. Less than one-third of this is furnished by water power, while something like 2,000,000 horsepower is still undeveloped in the very heart of the cotton field.

One of the pioneer companies to organize for this work was the Catawba Power Company. The first plant was built on India Hook Shoals on the Catawba river, 18 miles from Charlotte, N. C. This plant commenced operation in March, 1904, and the quick sale of the entire output (10,000 horsepower) led Dr. W. Gill Wylie, president of the company, to consider the advisability of developing other plants in different parts of the country. The result was the formation of the Southern Power Company, with a capital of $10,000,000, to acquire and develop a sufficient number of water powers to furnish power to a section of the country 130 miles in length and 100 miles in breadth in the heart of what is known as the Piedmont region, the richest and most fertile section of the Carolinas. This section is dotted with cotton mills throughout its length and breadth and 150,000 horsepower is used, generated mostly by steam.

Eight undeveloped water powers on the Catawba river, besides that at the Catawba station, were taken over and one on the Broad river, the water rights covering a distance of 110 miles on the Catawba river, giving an aggregate head of 500 feet, and an average capacity of about 150,000 horsepower. At the outset it was clear that the most practical plan of development involved beginning at Great Falls, and three generating plants hydraulically "in series" were planned. These are designated the Great Falls, Rocky Creek and Fishing Creek stations. The original plan was slightly modified, however, by distribution conditions, which made it advisable to establish a generating station farther up toward the center of the area covered by the system before putting in the Fishing Creek station. Consequently, as soon as the Rocky Creek plant was about completed, work was begun on a 16,000-horsepower generating station at the Ninety Nine Islands (see Fig. 11).

FIG. 1. VIEW OF GREAT FALLS STATION AND DAM FROM THE TAIL STREAM

Problems Involved

The engineering problems involved were somewhat different from those found in any other system of comparable size. It was not definitely known how much power could be marketed in any one town or district, which left unsettled the capacity of the lines and amount of territory to be covered. This complicated the question

of voltage regulation, as did also the fact that power would first be taken off at two or three points toward one end of the system, and finally at ten and probably a great many more points over the whole area covered. It was also necessary to make provision in the scheme for line regulation in order that the most economical method of passing water from the upper stations to those lower down in dry seasons could be practiced. The generators and step-up transformers were purchased under specifications covering a 15 per cent. rise in voltage and will operate under full load continuously under these conditions. Taps were also put on transformers in case this increase of voltage was not sufficient.

it would help matters materially to be able to throw a large amount of power on the system at one point in order to give other stations on the system sufficient time to cut in before the load would become too large to be carried. The three projected stations in the neighborhood of Great Falls would together be capable of carrying a load of 90,000 horsepower, so it was decided that this point be made the principal one of the system.

In order to carry out this idea and to make the system pliable, it was further decided that the equipment of these three stations should be subdivided into four units, consisting of two generators and three transformers, at each station; that the high-tension leads from each bank of

the insulation; that choke coils and series transformers should withstand a shop breakdown test of 120,000 volts for one minute, and that the complete high-tension equipment should withstand a breakdown test of 100,000 volts to ground after installation.

Great Falls, on the Catawba river, 50 miles below Charlotte, N. C., and 24 miles from Camden, S. C., was selected for the first development. Surveying was begun in June, 1905, and the water was turned on early in March, 1907. This station is now working in parallel with the Catawba station, the auxiliary steam plant having been shut down a year ago, and a sister station has been built at Rocky Creek, 1¼ miles from the Great Falls station, and

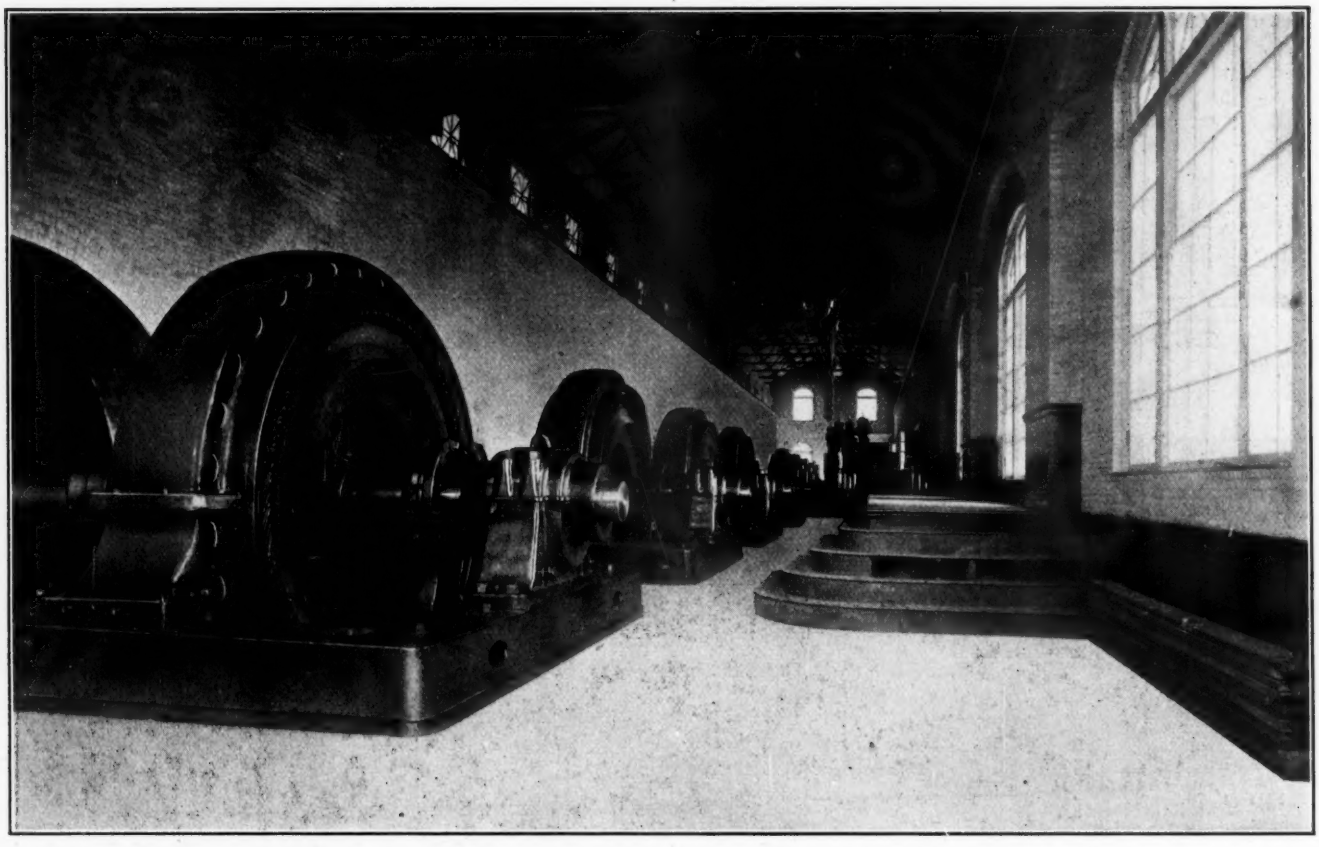


FIG. 2. VIEW IN THE GREAT FALLS GENERATOR ROOM

It was estimated that at least one hundred substations would be necessary to dispose of 150,000 horsepower and in the neighborhood of 800 miles of transmission line, no point of which would be more than 60 miles from the nearest power house. The large number of small substations and the comparatively short transmitting distance made it feasible to adopt 44,000 volts for the potential at receiving stations.

From the foregoing it is evident that the design of the switching arrangements necessary to facilitate the location of a fault in a line or substation, and for synchronizing after the fault had been repaired or the line cut out, was a serious problem. Much study was given this subject and the conclusion was reached that

transformers should pass through one switch and connect with a switching station common to all three stations; that the busbars in the switching station should be divided into as many sections as there would be outgoing lines and arranged so that in case of necessity one or more units in any one station could feed into one or more lines; that provision for synchronizing should be made at first only on the switch between the transformers and the low-tension busbars, and that provision for synchronizing at the old Catawba station should be made on the low-tension side of transformers.

It was also deemed advisable to use as few switches as possible and to have a large factor of safety in all, with regard to both the current-carrying capacity and

put into operation. These three stations are supplying current to 385 miles of transmission—or more accurately, high-tension distribution—lines, other stations are being laid out, and the construction of 240 miles of 100,000-volt transmission line is in progress. The potential of the existing lines is 50,000 volts at the Great Falls end and 44,000 volts at the substations.

Great Falls and Rocky Creek

These two stations are mates, the buildings and equipment being practically the same in both. The only important difference is in the exciter equipment, which will be described in detail farther on in this article. Fig. 2 is an imperfect view of the interior of the Great Falls generat-

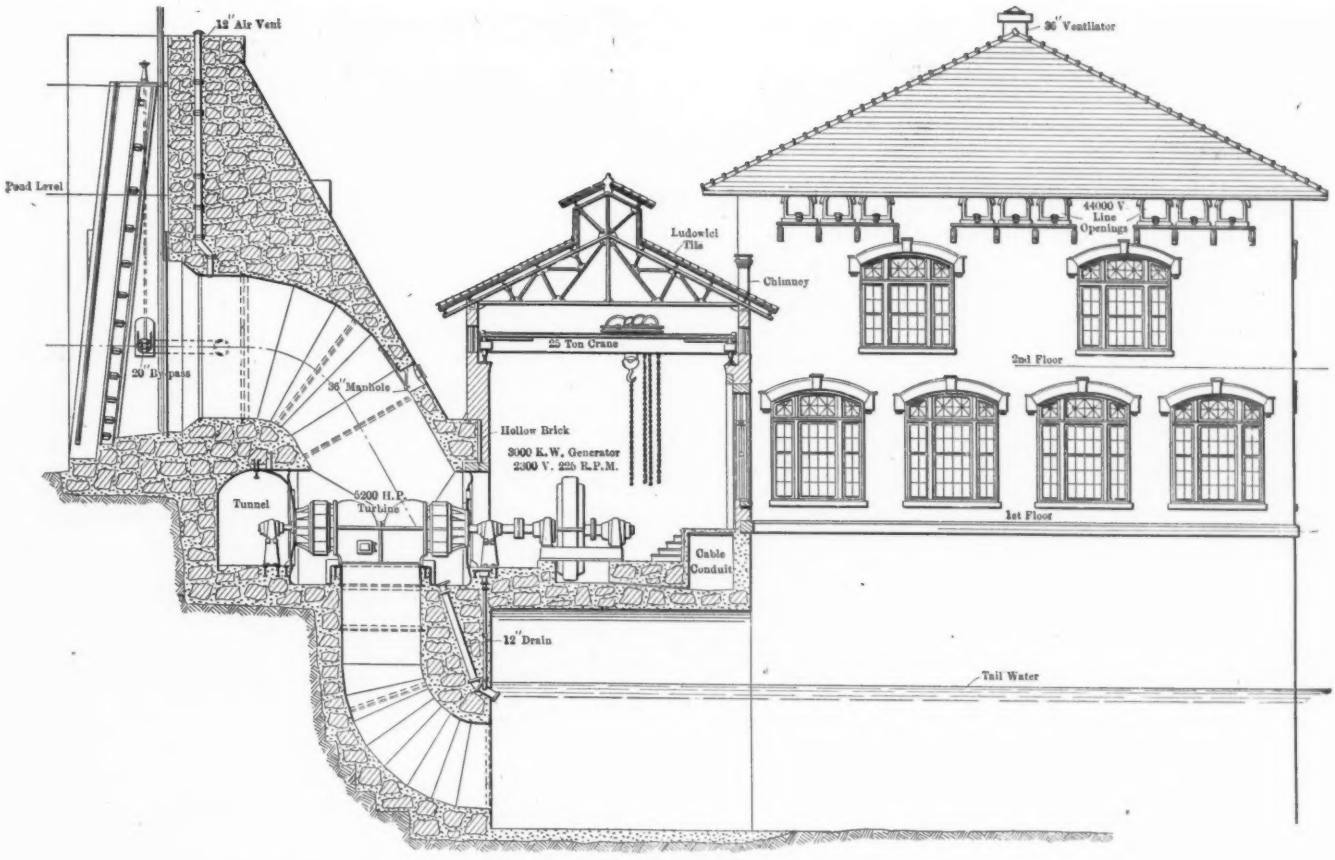


FIG. 3. SECTIONAL ELEVATION OF ROCKY CREEK GENERATING HOUSE, INTAKE AND HEAD GATES

ing room, which is 250 feet long by 37 feet wide and is 30 feet pitch. The transformer and switch house is 85 feet long by 71 feet wide, and is three stories high. The basement, which is on a level with the cable conduit and contains the cables and pipe work, is 8 feet pitch. The next story, which is on a level with the switchboard gallery and contains transformers and low-tension switching apparatus, is 22.8 feet pitch, and the third story, in which at present are the high-tension switches, busbars, choke coils and lightning arresters, is 22 feet pitch. Both buildings are of fireproof construction throughout, red pressed brick outside and light gray inside. The roof is built of large tile made of reinforced concrete with a waterproofing burned into it. The vertical cross-section, Fig. 3, and the plan view, Fig. 4, show the construction of the buildings, intake flumes and tail flumes, and the general arrangement of the generating equipment. Fig. 5 shows the dam at Rocky Creek during construction; the cross-section of the unfinished portion on the right is clearly shown.

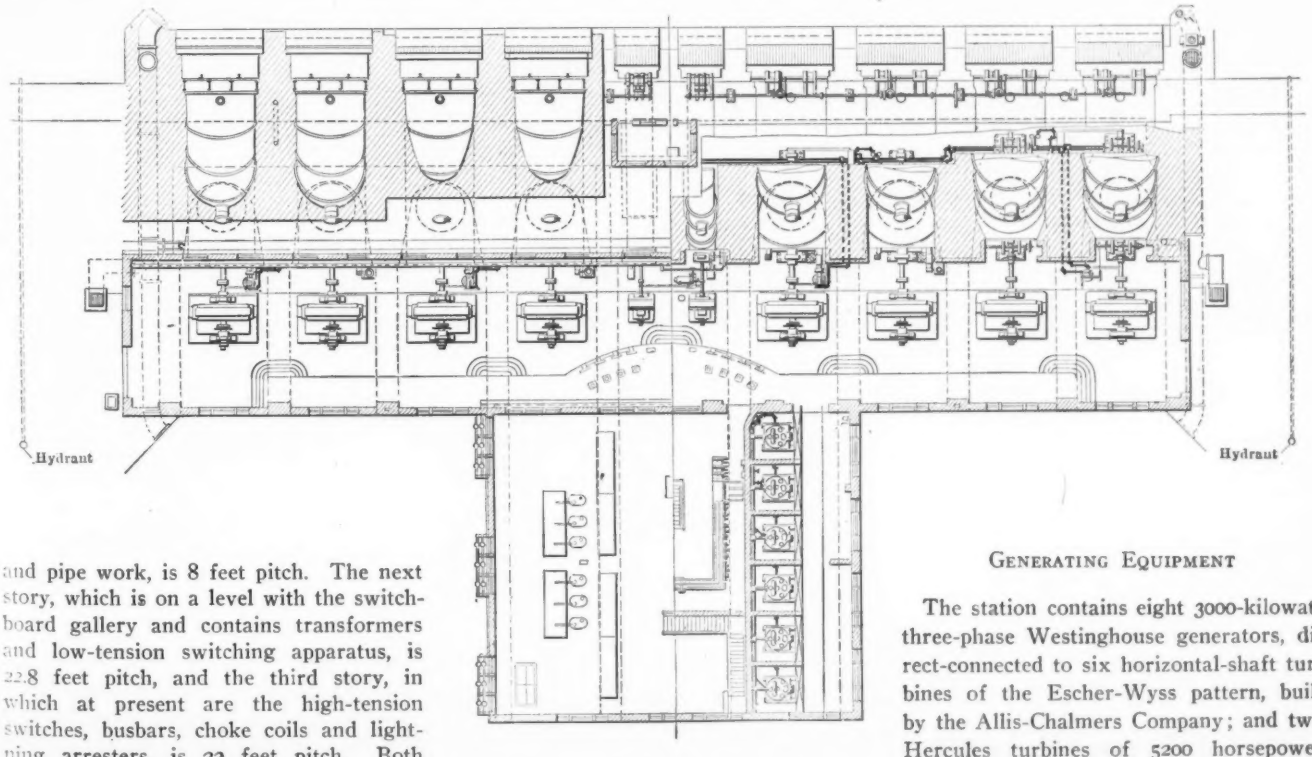


FIG. 4. PLAN OF GREAT FALLS STATION

GENERATING EQUIPMENT

The station contains eight 3000-kilowatt three-phase Westinghouse generators, direct-connected to six horizontal-shaft turbines of the Escher-Wyss pattern, built by the Allis-Chalmers Company; and two Hercules turbines of 5200 horsepower capacity each, built by the Holyoke Ma-

FIG. 5. THE ROCKY CREEK DAM DURING CONSTRUCTION

chine Company, with two 400-kilowatt, 250-volt exciters, each capable of carrying the total exciter load. The main generators were designed for an efficiency of 96 per cent. and to operate at full load at any voltage between 2200 and 2530, with 80 per cent. power factor, with a rise in temperature not to exceed 35 degrees Centigrade at any part. Tests have shown that the machines more than meet the specifications. They are driven at 225 revolutions per minute and deliver current at 60 cycles. Each two generators are connected in parallel through power-operated switches to a bank of three 2000-kilowatt step-up transformers connected in delta. This arrangement gives four complete 6000-kilowatt units capable

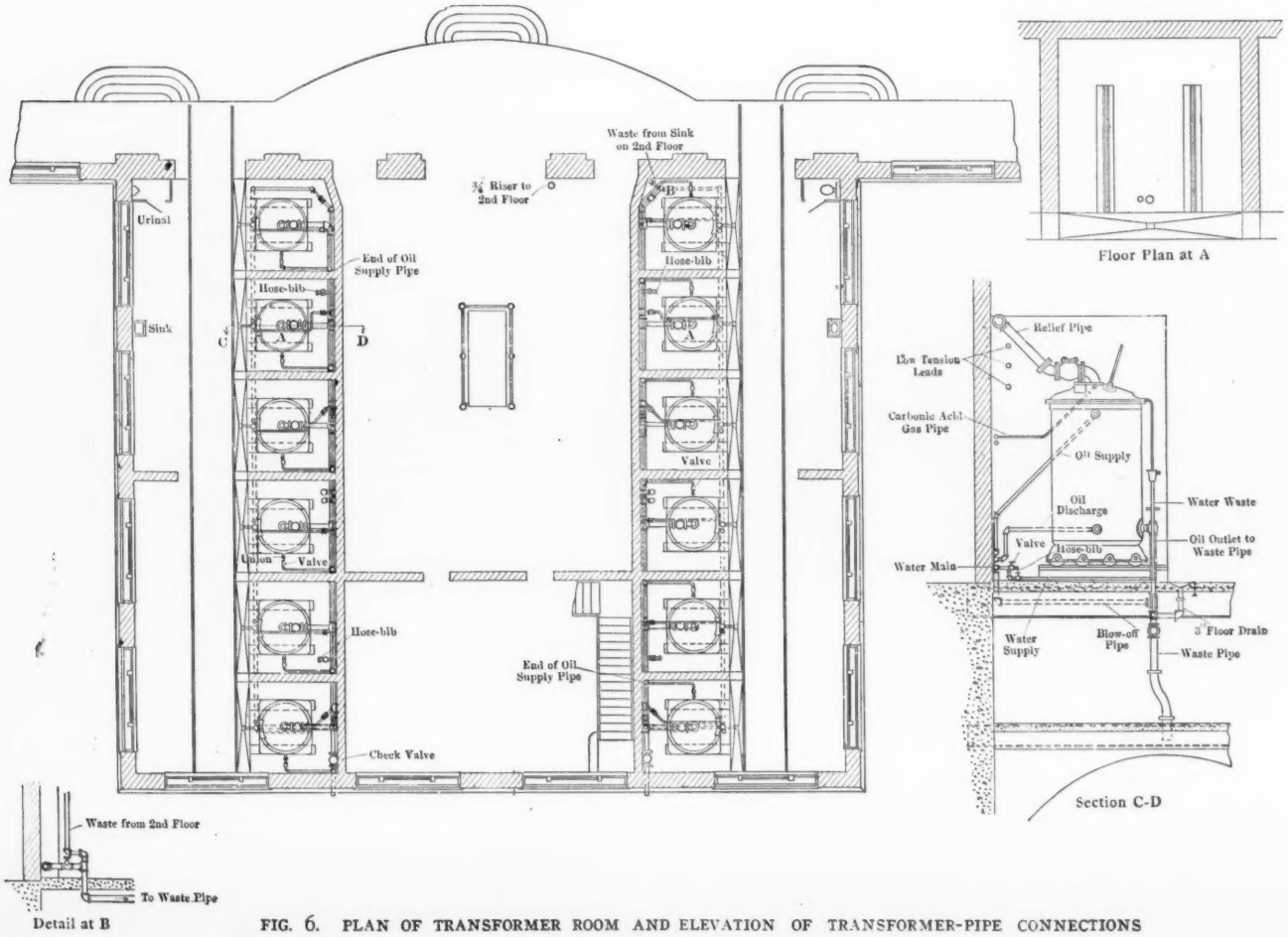


FIG. 6. PLAN OF TRANSFORMER ROOM AND ELEVATION OF TRANSFORMER-PIPE CONNECTIONS

of being run independently or in parallel, as may be found necessary.

The generators are controlled from pedestals standing in front of instrument posts, arranged in an arc of a circle to enable the operator to see all instruments without moving from one point. The advantage of the instrument posts and control pedestals in comparison with panel boards is that the operator can look over the pedestals and under the instruments at any machine which he is putting in service. On each of the eight instrument posts are mounted a 3000-volt voltmeter, a 1500-ampere ammeter, a 4500-kilowatt indicating wattmeter and a 400-ampere ammeter in the field circuit of the generator. On posts Nos. 1, 3, 6 and 8 are also mounted busbar voltmeters. To avoid confusion these are in a different type of case from the generator voltmeters. On posts Nos. 2 and 7 frequency meters are mounted and on posts Nos. 4 and 5 synchroscopes are mounted.

On the control pedestals are mounted the controllers for operating the oil switches, the hand wheels for operating the field rheostats, and the field switches; jacks used in calibrating instruments are also mounted on these pedestals.

Transformers, Switches, etc.

All transformers are oil-insulated and water-cooled; they are located in separate fireproof compartments, as shown in Fig. 6, and mounted on trucks to facilitate handling. The tanks are made of heavy boiler plate which will stand 150 pounds pressure per square inch, and the tops are provided with check valves opening into a 6-inch pipe which leads to the tail water, to provide for any explosion which might take place due to the ignition of oil gas. The transformers are controlled from a standard blue Vermont marble board set in an archway between the control pedestals in the generating room and the low-tension switch room. For each bank of transformers the board carries an ammeter, a power-factor meter and an integrating watt-hour meter. In this archway are also set the panels for controlling the switches in the high-tension switch room. Ammeters only are used on the outgoing feeders.

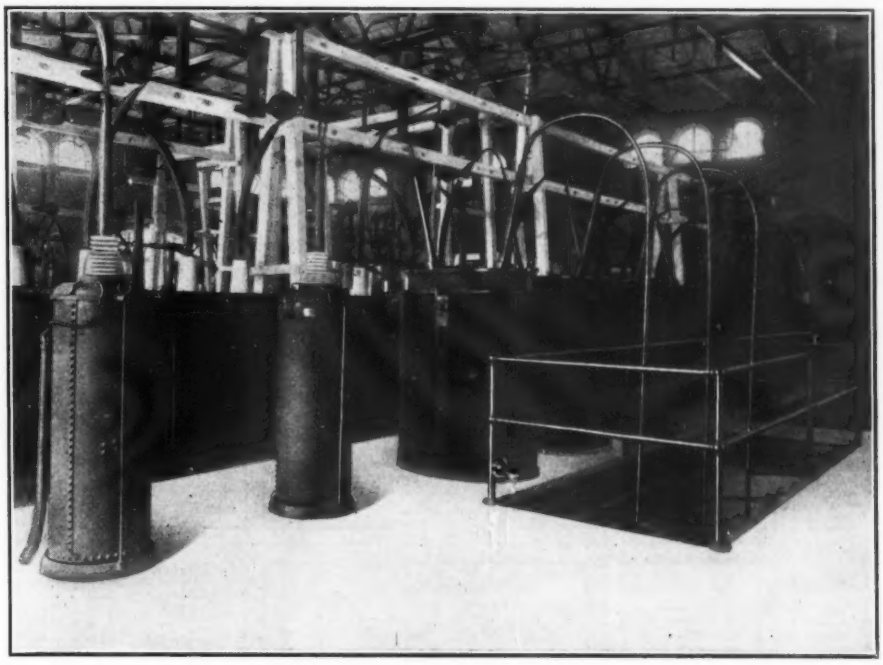


FIG. 8. VIEW IN HIGH-TENSION SWITCH ROOM

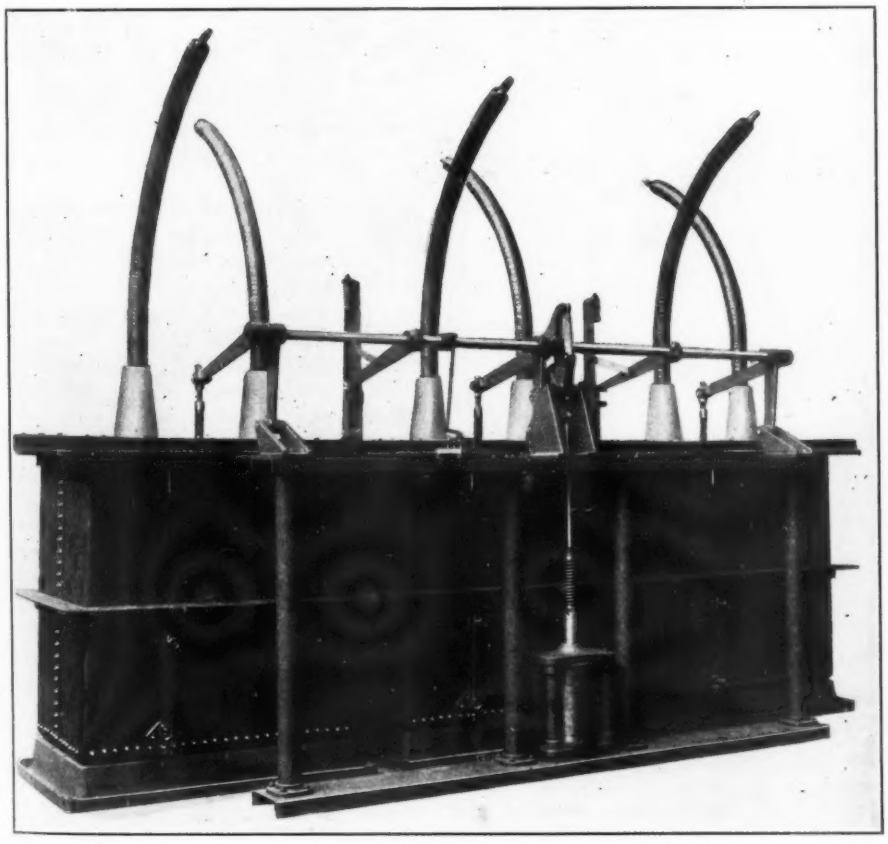


FIG. 7. SOLENOID-OPERATED OIL SWITCH

The low-tension switches and busbars are mounted in a concrete structure forming three sides of a rectangle in a separate room. The oil switches and circuit-breakers are each capable of breaking the entire output of the plant on short-circuit; they are of the solenoid type, shown by Fig. 7, and operated with current from the exciter busbars.

The switchboard is located on a gallery raised above the power-house floor, but on a level with the transformer room and low-tension switch room. In the space below are the field rheostats, exciter busbars and control wires. This gallery is narrowed and extends in either direction to form a conduit for the cables between the generators and the transformers. These cables are laid on concrete shelves provided for the purpose, and are brought through floors and walls in vitrified conduit.

All the 44,000-volt apparatus is in an entirely separate room, occupying the third story of the transformer house. The high-tension switches are capable of breaking the entire output of the station on short-circuit. The three poles of these switches are mounted in individual boiler-plate tanks sufficiently strong to resist any explosion that might be caused by opening the circuit during short-circuits on the high-tension line. The line and transformer switches are controlled from

the panel board in an archway between the generator room and the low-tension switch room. All high-tension conductors in the buildings are made of insulated copper pipe.

Fig. 8 is a view in the high-tension switch room, and Fig. 9 is a schematic diagram of the main wiring and switching arrangements in the Great Falls and Rocky Creek stations, and this will be used also in the Ninety Nine Islands station when it is built. This illustrates clearly the banking of the transformers and generators into four equivalent units or "batteries."

The equipment at Rocky Creek is exactly the same as that at Great Falls, except as to the arrangement of the exciters. At Great Falls the two exciters are driven by individual water wheels. At Rocky Creek the two exciters and a 600-horsepower induction motor are set in line with the shaft of a single water wheel, and clutches are provided by means of which either the water wheel or the motor can be used to drive the exciters. Fig. 10 is a diagrammatic plan of the arrangement.

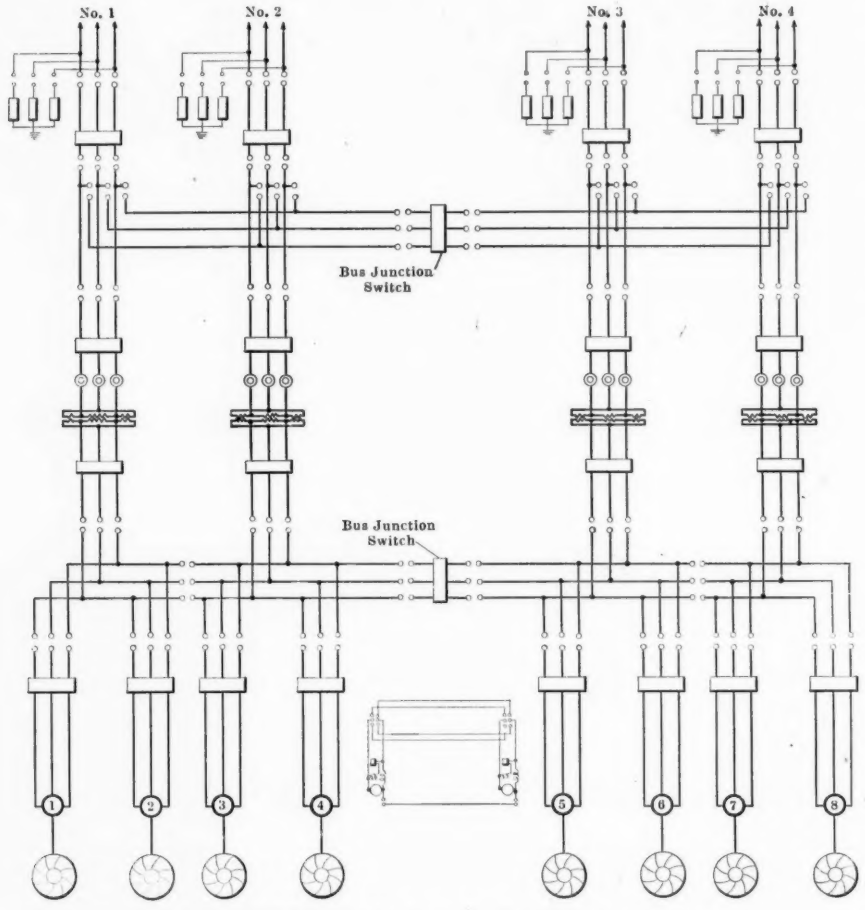


FIG. 9. SCHEMATIC DIAGRAM OF MAIN-STATION CONNECTIONS

The Catawba Station

The original station at Catawba contains four 750-kilowatt and four 900-kilowatt General Electric generators driven by Holyoke turbines and delivering three-phase currents at 13,000 volts to step-up transformers on the main 50,000-volt system. This station also supplies a separate system extending to Rock Hill, Pineville and other nearby towns, working at 10,000 volts at the receiving substations. This system takes current directly from the generator busbars. The Catawba power house serves also as a switching station for the 50,000-volt lines radiating northward from it, and is provided with facilities for connecting the short line to Rock Hill and other towns to the main system through step-down transformers. That is, the station contains three 2000-kilowatt delta-connected transformers with switches whereby they can be used to step up current from the generators and deliver to the main system, or to step down from the main system to the short line.

Transmission Lines and Connections

Fig. 11 is a map of the system, including lines under construction and those which it has been definitely decided to build. The double lines between the Great Falls district and the town of Concord, passing through the Catawba station, give some indication of the growth of the system, but even more significant than these are the double 100,000-volt lines now being built from Great Falls northward to Greensboro and westward to Greensville, S. C. These are transmission lines in the strict sense, while the 44,000-50,000-volt lines are really primary distribution feeders with respect to the general system. This is more clearly shown by Fig. 12, which is a diagram of the connections at all of the important stations and substations and also gives the distribution of power amongst the principal secondary stations.

At the generator end of each 100,000-volt line a 12,000-kilowatt group of two-to-one transformers connect these lines with the 50,000-volt busbars; at Salisbury, the two sets of lines will be tied together through a 9000-kilowatt group and at Spartanburg through a 6000-kilowatt group of two-to-one transformers. From Fig. 11 it is evident that each of the important points receives current from two or more directions; consequently, the supply cannot be cut off by trouble on any one feeder.

The main trunk line from Great Falls to Catawba station is 33 miles in length. It is carried on steel towers and consists of two three-phase circuits. Fig. 13 is a view of this line. Three sizes of tower are used, standing 35, 43 and 50 feet, respectively, from the lowest wire to the ground, as the nature of the country demands; 500-foot spans are used in general. The conductors are each built up of six strands of No. 6 copper, with a hemp center, equivalent to No. 000 Brown & Sharpe gage. Tests of this conductor gave a breaking strength of about 62,000 pounds per square inch for the individual strands, and about 58,000 pounds per square inch for the complete cable. The elastic limit was taken at 40,000 pounds, two-thirds of which gives 3330 pounds per conductor as the maximum working strain. To be on the safe side this was taken at 3000 pounds and the corresponding sag adopted, assuming a maximum change in temperature of 125 degrees Fahrenheit. After the lines were strung and before current was turned on they were subjected to a severe sleet storm and no breaks occurred.

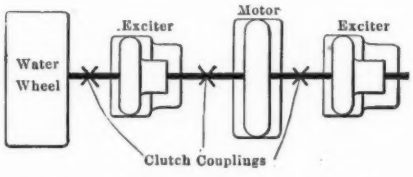


FIG. 10. ARRANGEMENT OF ROCKY CREEK EXCITERS

The trunk lines are sectionalized at points of transposition in order that in case of trouble on one line one section of the other may still be used and the remaining parts of both lines paralleled. The ordinary line towers are built of galvanized-steel angles with rod braces, and will withstand a total pull of 8000 pounds at the top. The sectionalizing and transposition towers are similar to the ones

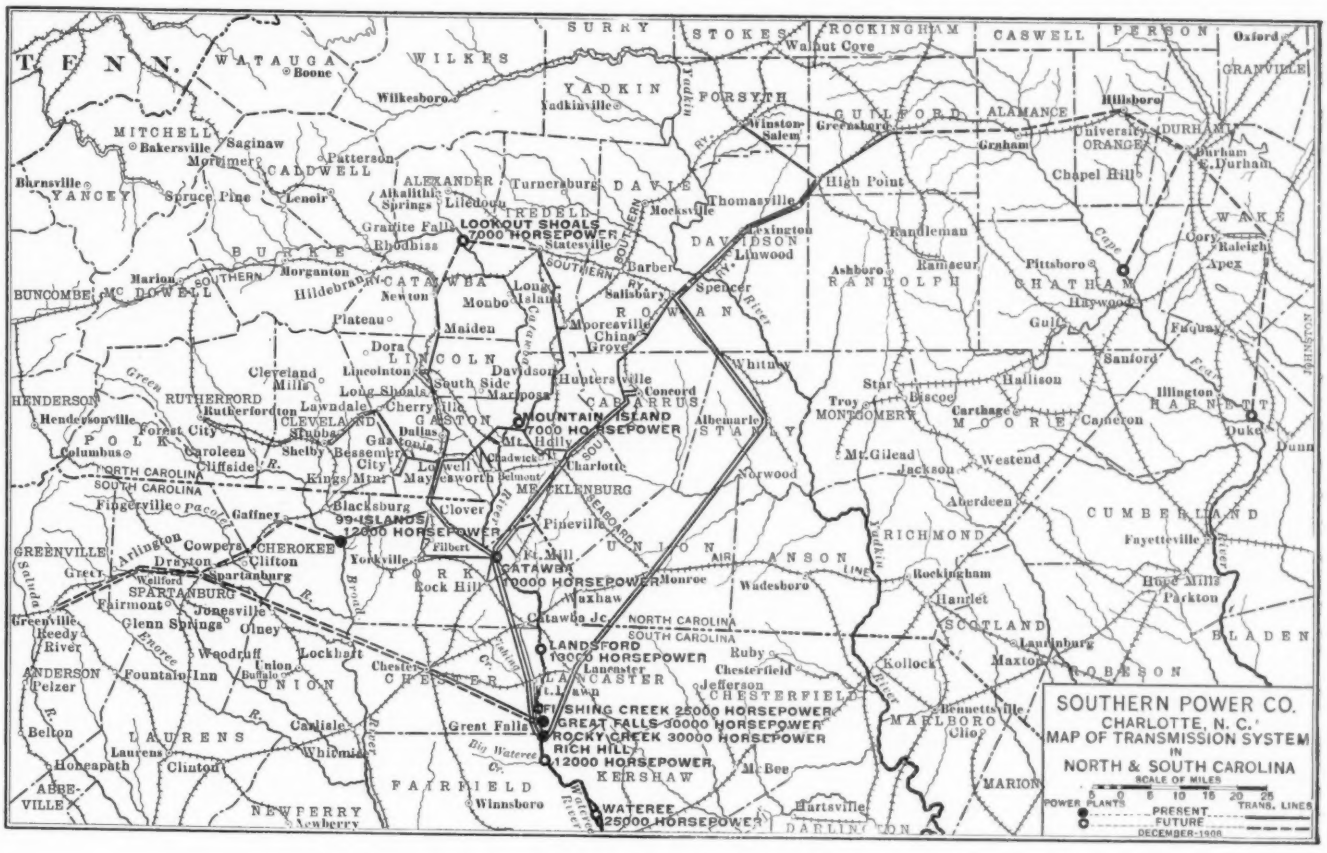


FIG. 11. MAP OF THE SOUTHERN POWER COMPANY'S TRANSMISSION SYSTEM

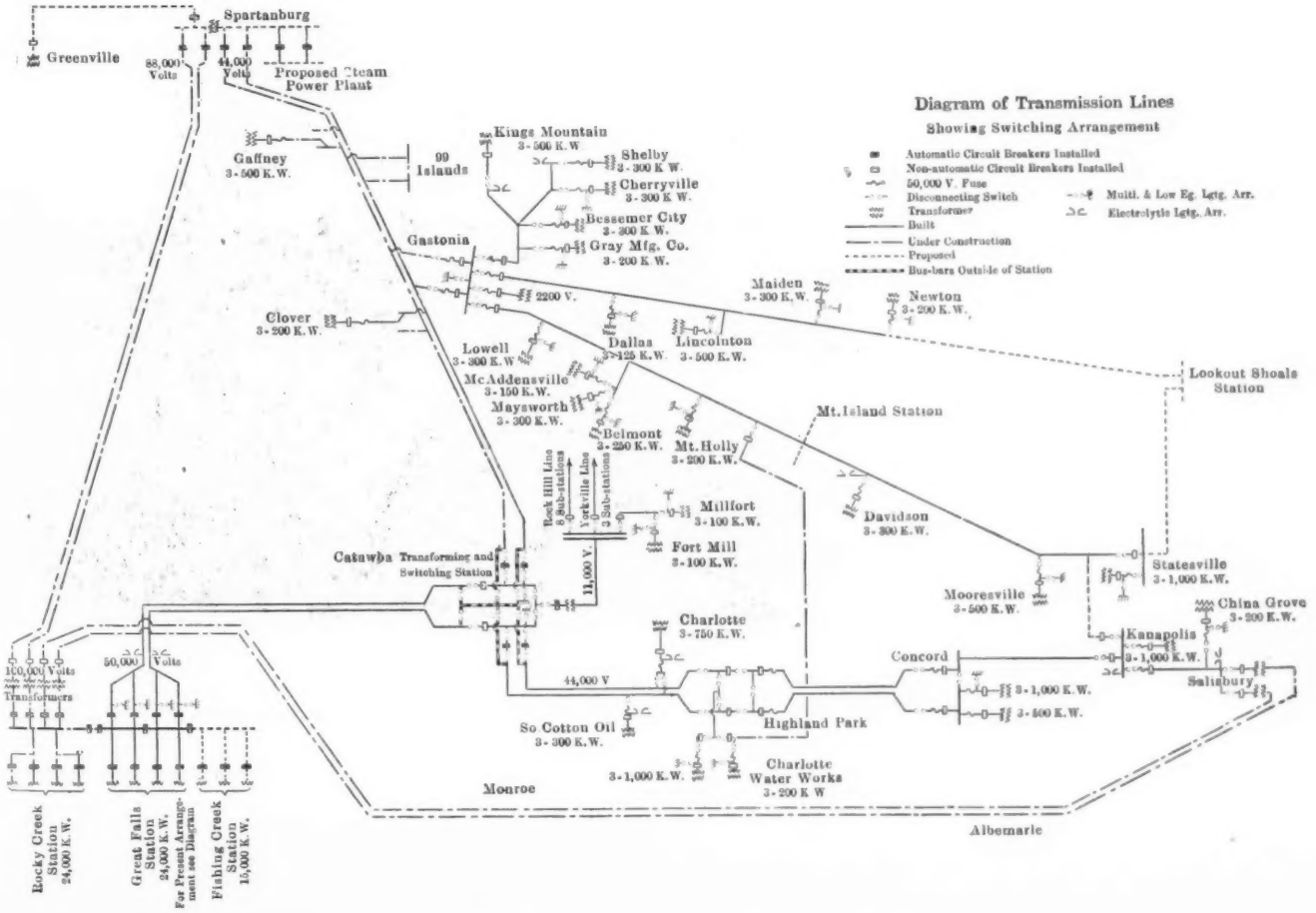


FIG. 12. DIAGRAM OF TRANSMISSION AND FEEDER CIRCUITS

used at angles greater than 30 degrees or for terminal or tap-off towers, except for the arrangement to which lines are connected. They were tested to 6000 pounds per conductor. The line between Catawba station and Gastonia, a distance of 25 miles, is carried on the same type of tower, though it consists of only one circuit of No. 00 Brown & Sharpe stranded copper at present.

The remaining 44,000-volt lines now completed or under construction are carried on 35-foot wood poles, 8 inches in diameter at the top, and spaced 150 feet apart. The cross-arms are 4¾ inches by 5¾ inches by 7 feet hard pine treated with hot carbolineum. The pins are iron and a special iron cap was designed to accommodate the top pin and to support a galvanized pipe, which in turn supports a grounded wire. An iron pin was also designed which has proved very satisfactory, not only with regard to convenience and strength, but also with regard to cost. The shank is cast and the pin head may either be cast or forged, according to strength required. These pins with cast heads were used on terminal towers and three of them proved amply strong. The bolt can be made any length and makes a very convenient method of fastening an insulator to a wall or wood beam. The heads are cemented in the insulators either at the factory or before insulators are taken out of the shipping crates.

On account of using towers that would not withstand the strain of a broken wire, a tie-clamp had to be designed that would allow the wire to slip through in case of emergency. The clamp is made of cold-pressed steel, galvanized, and will allow the conductor to slip at about 350 pounds pull. In other words, the strain will be distributed amongst ten towers, leaving an ample margin for wind pressure. This clamp costs less than an ordinary tie-wire.

The line insulators were specially designed to meet the views of the company's engineers and were mostly made by the R. Thomas and Sons Company. Those on the 44,000-50,000-volt lines are of the construction shown by Fig. 14. They will arc over at approximately 88,000 volts under a precipitation test of ¼ inch of water per minute at a pressure of 50 pounds per square inch from a sprinkler nozzle played on the insulator at an angle of 30 degrees above the horizontal. They were all subjected to a dry test of 120,000 volts for ten minutes. The insulators used on the 88,000-100,000-volt lines are of the suspension double-petticoated type 14 inches in diameter.

Substation Equipment

The substation transformers were all purchased under one specification in order that they could be changed from one point to another in case of a burnout, or in case the output became too large for the size of the transformer. They are capable of carrying full load continuously at 5 per cent. above and 10 per cent. below the rated voltage, taps being provided for these voltages on the high-tension side.

In the small transformer substations the cost of automatic high-tension switches such as are used at the generating stations would be excessive and a comparatively cheap oil switch, with the poles mounted separately in brick cells, and equipped with expulsion fuses (of type similar to what is known as the "T. D." fuse made by the General Electric Company) is used. Before the adoption of these fuses they were tested on short-circuit on lines of large capacity and proved very satisfactory. It is hoped that these fuses will prove more satisfactory than the automatic switch in that the series transformers necessary for the circuit-breaker, which has been such a source of trouble in lightning storms, are now not necessary.

Lightning Protection

An equal number of General Electric multiple-unit and Westinghouse low-equivalent lightning arresters, together with horn arresters, have been used in the main and substations, and an electrolytic lightning arrester is now being installed for comparison with the arresters of the older type. In addition to the lightning arresters, grounded wires are strung over all transmission lines. On the twin steel line towers two grounded wires are used, and on the pole line one 9/32 galvanized S. M. strand. Each pole is grounded by attaching to the side thereof a galvanized plate 12 inches

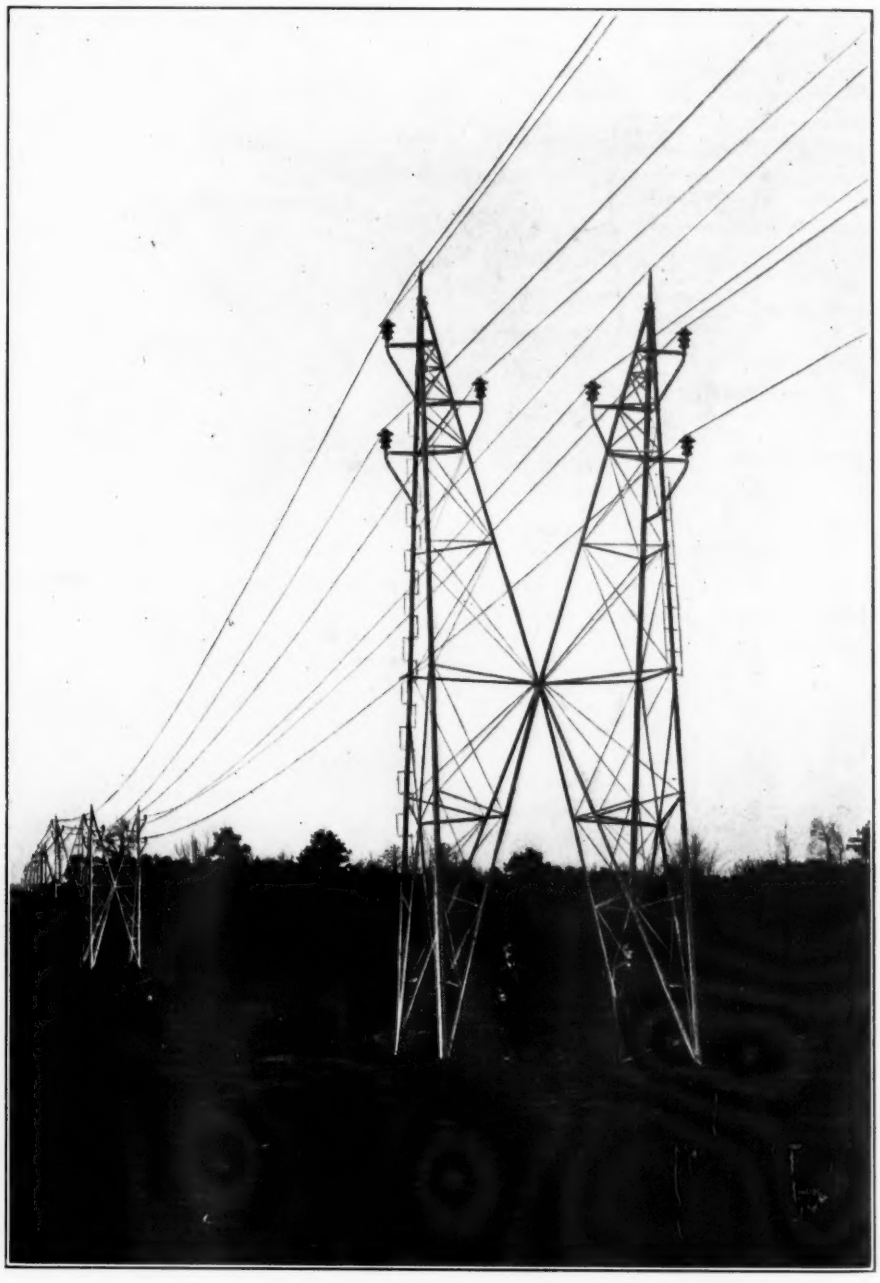


FIG. 13. TRUNK LINES BETWEEN GREAT FALLS AND CATAWBA

square of No. 20 metal. This plate is connected with the overhead wire by means of a No. 8 iron wire. The effectiveness of this grounded wire has been questioned, but the company's experience on the old lines has shown that it is well worth the money spent on it.

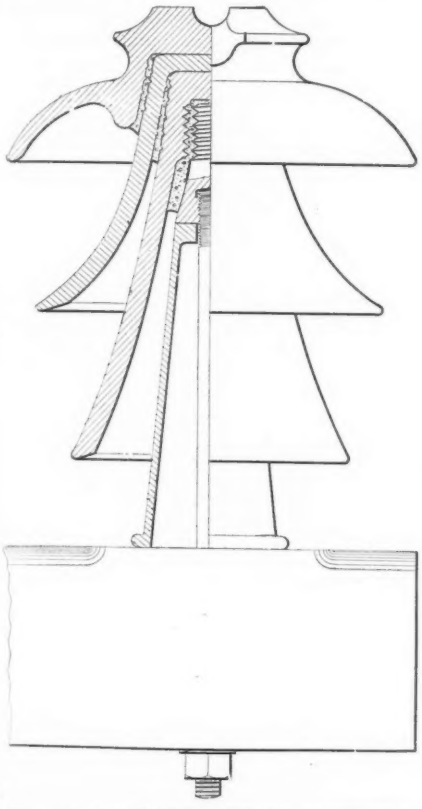


FIG. 14. INSULATOR USED ON 50,000-VOLT LINES

current. Smaller choke coils of air-cooled type are used in substations.

In General

As the load on the system is constantly increasing and changing in distribution characteristics, any specific statement concerning it would be out of date by the time this article actually appears in print. It is of interest to note, however, that on November 1, more than one hundred cotton mills were operated by current from the system; all of the street lighting in Charlotte, Salisbury, Concord, Statesville, Lincolnton and some twenty smaller towns was being done by it, and countless small factories and industrial plants depend on it for their motive power. In the cities and towns where general lighting and power service is supplied, the current is stepped down to 2300 volts for distribution by the local primary network. In most of these places the Southern Power Company merely sells power "in bulk," so to speak, to local companies who formerly operated central-station plants; the prime movers in most of these plants have been discarded, and the station equipment restricted to transformers and series-circuit regulators, reducing the problem of attendance to a state of beautiful simplicity. In many of the towns, however, the power company maintains its own substations and deals directly with the consumers.

The success and rapid progress of the company was primarily due to two men —Dr. W. Gill Wylie, the president, whose foresight, energy, and financial ability discerned the opportunity and provided

scheme. During the past four years Mr. Lee has had an invaluable assistant in J. W. Fraser, who has practically the entire responsibility for the mechanical and electrical portions of the work. Since Mr. Fraser's advent, in the spring of 1904, Mr. Lee has confined his attention to the

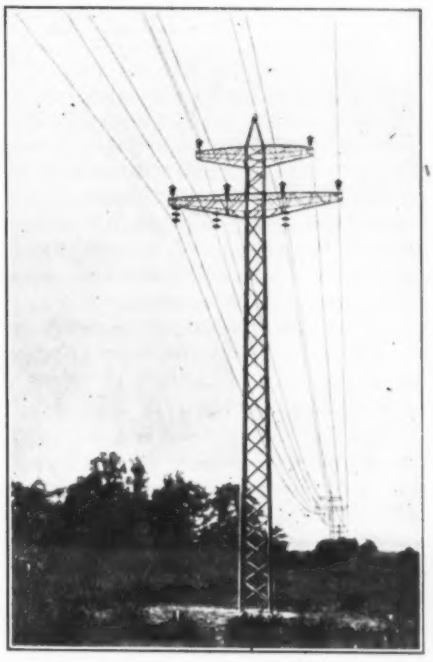


FIG. 15. TOWER USED FOR LINES IN CITIES

practical construction work—the executive side of the engineering department. During this period the load carried has increased from 300 horsepower to 50,000 horsepower for ten hours.

Acknowledgments are hereby made to

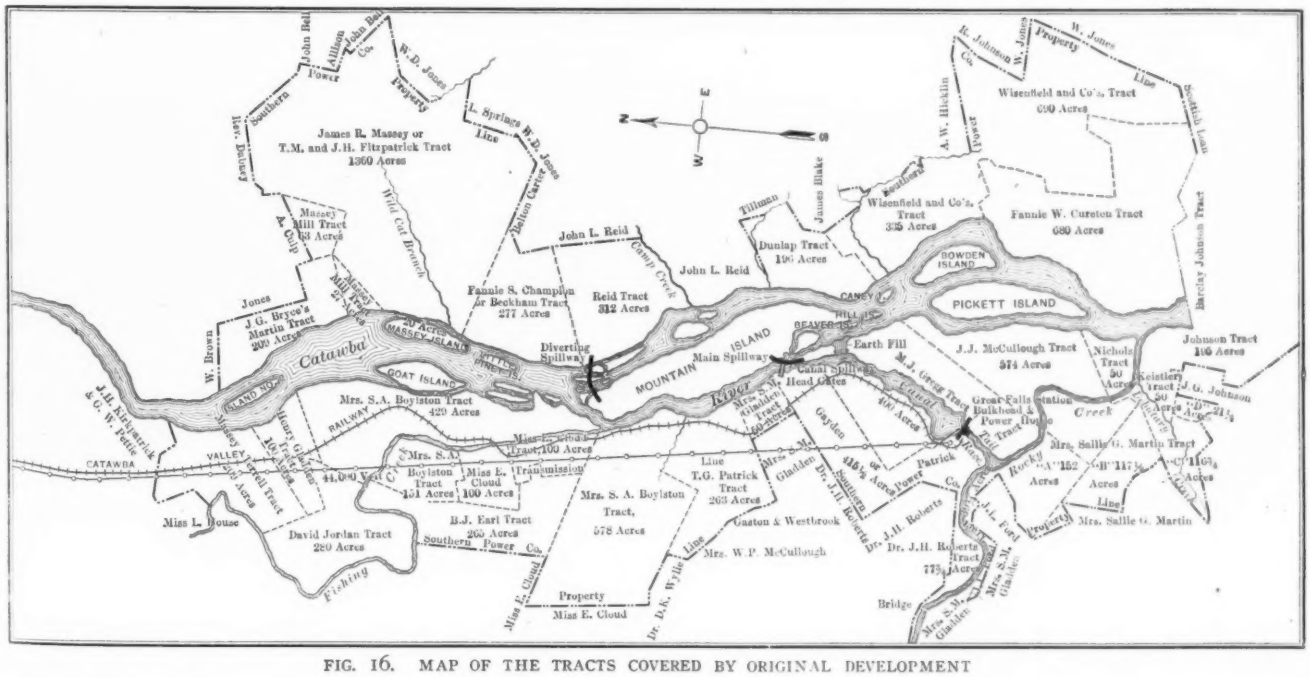


FIG. 16. MAP OF THE TRACTS COVERED BY ORIGINAL DEVELOPMENT

Choke coils of the oil-cooled type are used at the generating stations. The impendance drop in these is about 1 per cent. of the line voltage and the resistance loss about 1800 watts when the transformer bank is carrying normal full-load

the commercial requisites for grasping it, and W. S. Lee, Jr., chief engineer, whose sound engineering judgment and executive ability are responsible for the working out of the details and the technical application of Dr. Wylie's industrial

Messrs. Lee and Fraser for the information presented in this article and to Mr. Fraser for his cheerful coöperation in the preparation of it, as well as for several drawings and photographs made especially to illustrate the descriptive text.

The Use and Abuse of Globe Valves

Plain Descriptions of the Principal Features of the Different Types, with Practical Suggestions for the Guidance of Engineers

BY W. H. WAKEMAN

The ordinary globe valve is a mechanical monstrosity, illogical and crude when viewed as a machine, but owing to its convenience of operation and low cost of repairs it has gained well deserved popularity among engineers and steam users. A few suggestions concerning its proper use, and in disapproval of the abuse to which it is often subjected, ought to prove profitable to all concerned.

Fig. 1 illustrates the first thing that I do to one of these valves when it is to be used in my plant. A stout bench, well braced from the ceiling to hold it down firmly, is shown at *A*, on which there is a pipe vise *B*. A short piece of pipe of a size suited to the valve is clamped in this vise, and the valve is screwed on it. A large monkey wrench is fitted to the bonnet, and a quick, strong pull on the handle loosens the screw and removes the bonnet without further trouble under ordinary conditions. The reason for using a large wrench for this job is because a small one is much more liable to spring and round off the corners without loosening the bonnet.

The reason for removing the bonnet at this time is owing to the assumption that it was screwed on very tightly when first assembled; therefore, if not loosened before it is subjected to the action of steam, it will be almost impossible to take it off when it must be repaired in order to stop a leak at this point. If it is replaced and brought to its proper seat by reasonable pressure on the wrench handle, it will be steam- and water-tight, and later it can be removed without serious injury. The use of lead or anything else on these threads is not recommended, for whatever is applied will prove detrimental when the bonnet is again removed after long service. When considering this point it is well to remember that the joint is not made in the threads (like a pipe joint), but where the two flat surfaces come together and are held in close contact by the threads.

The next move is to unscrew the packing nut, remove whatever packing may be there, and fill the nut as nearly full as possible with asbestos wicking, either oiled or coated with graphite, according to the conditions under which the valve is to be used. It is surprising to note the indifferent way in which engineers sometimes pack these valves. A short piece of packing is put in and the nut is screwed down as far as it will go, which means that nearly all of the threads on the bonnet are covered. If this prevents the escape of steam it is considered sufficient. When it does begin to leak, a wrench is applied and a hard pull brings it around perhaps one-quarter of a turn, but it will go no farther, and steam still blows out; consequently, pressure is removed from the pipe line, the nut is taken off, more packing is added (without removing the old material) and the nut is screwed on. The result is the same as before, but the process is repeated indefinitely, as the unsatisfactory results obtained do not suggest an improved method.

A better plan is to press the packing tightly into the nut with a packing hook, or other suitable tool, and wind it around the stem until it appears as shown in Fig. 2. The end of this packing is left so as to show the direction in which it

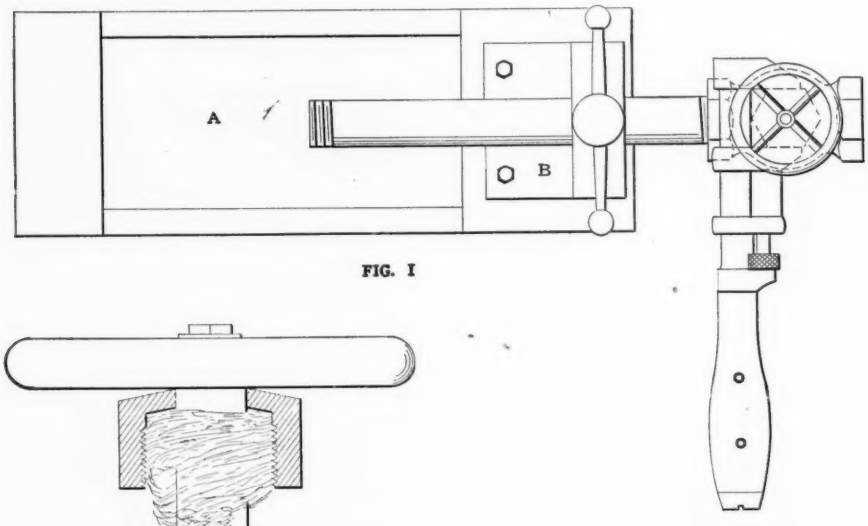


FIG. 1

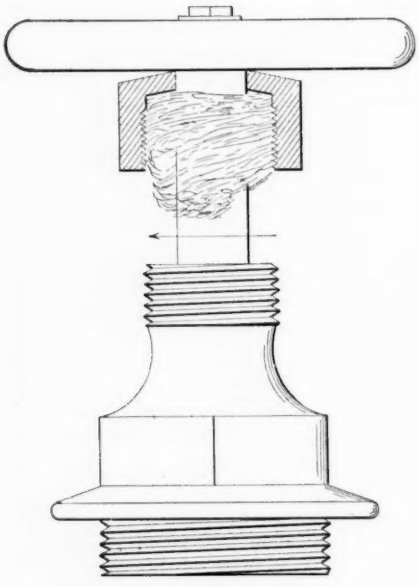


FIG. 2

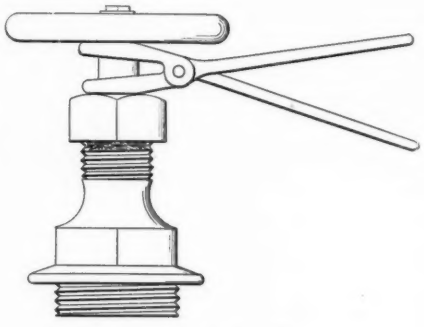


FIG. 3

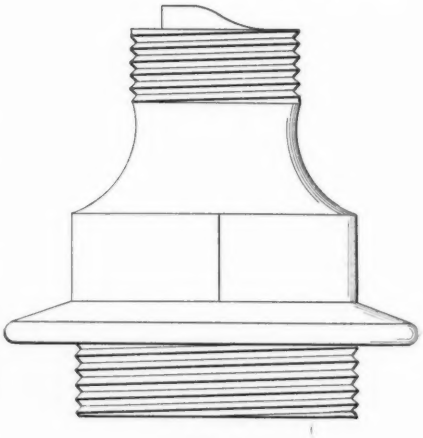


FIG. 4

should be wound, because the nut is turned as indicated by the arrow, in consequence of which action the packing will be smoothly pressed into place, whereas if it were wound in the opposite direction, turning the nut would unwind the packing and prevent smooth action. It ought to be wound around the stem in the opposite direction from that in which the nut is turned when screwing it on the bonnet.

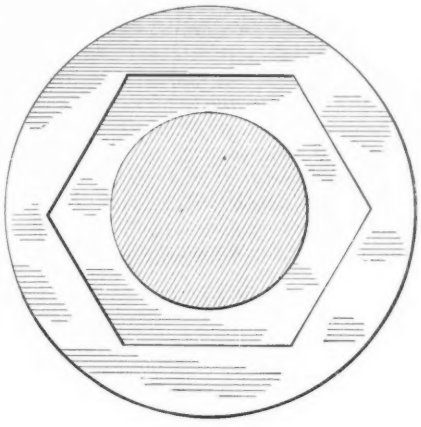


FIG. 5

Having thus filled the nut, it is pressed down until a pair of packing pliers can be inserted between the nut and the wheel, as illustrated in Fig. 3. These pliers are designed to open when pressure is applied to the handles (instead of closing in the usual way); consequently, the nut is forced down until it begins to screw on the bonnet, when a wrench is applied to it. Usually it can be turned until the packing is compressed into about one-half of the nut, then it ought to be unscrewed and another ring or two of packing put in.

This calls attention to the form adopted for the top of the bonnet on which the packing rests. Originally it was a plain, flat surface, and this is better than any other kind for the following reason: When the packing nut (or waste nut, as it is technically called) is unscrewed as described, the packing remains in it; therefore, more can easily be added until the desired amount is secured. If anything prevents free movement of the packing, it is pulled out of the nut and it must be replaced, but it is then loose and requires force to make it compact, as when it was first put in.

Fig. 4 illustrates a device that appeared on a certain kind of globe valve a few years ago, but it is not used much at present. The tapering side of it is presented to the packing when the nut is screwed on, but any movement in the opposite direction is opposed by the square edge which effectually pulls out the packing. About the first thing that I did with a valve of this kind was to take a flat file with a safe edge and file off these objectionable projections, leaving the top flat and smooth.

Another Device for Holding Packing

Fig. 5 represents another device for holding packing, consisting of a depression in the top of the bonnet next to the valve stem. This is of hexagon form, and when packing is forced into it by screwing down the nut, it cannot turn easily. To overcome what is an objectionable feature from my point of view, I put one ring into this depression and make it independent of the remainder of the packing used; therefore, after it has been forced downward into place, the top of the bonnet is smooth and practically flat. Valves of this kind that I have recently purchased contain a ring of fibrous packing nicely fitted to and forced into this cavity, thus leaving the top perfectly free from obstruction. This is an excellent idea, because it gives the engineer a chance to

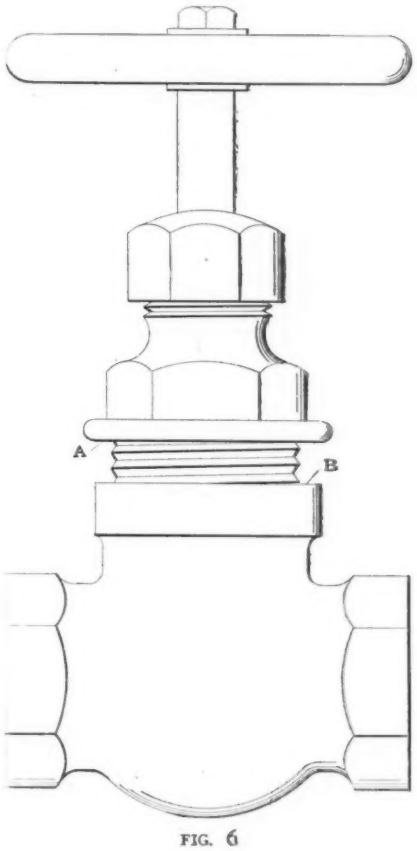


FIG. 6

choose which he will use. If this ring is not taken out he has a plain top on the bonnet, but if removed it leaves the hexagon cavity to prevent the packing from turning.

The object of the features shown in Figs. 4 and 5 is to prevent the nut from unscrewing when the valve is opened, but this very seldom happens in my plant, and there is no good reason why it should in others. If the packing is lubricated and the nut screwed down as it ought to be, no other precautions need be taken to hold the packing from turning. This refers to ordinary globe valves. There should always be enough in the stuffing box or nut to allow for screwing it down another revolution or turn, if it leaks after being in use for several weeks.

When the bonnet of a valve that has been used more or less is removed for any purpose, the surfaces at *A* and *B*, Fig. 6, ought to be thoroughly cleaned, then they will come together, metal to metal, when the bonnet is replaced. If there is a slight leak at this point when full pressure is on the valve, the only safe plan is to remove all pressure, take off the bonnet, clean the surfaces as described, and screw the bonnet on again, using force enough to secure perfect contact at all points. It is dangerous to force it down farther with full pressure on, as the leak may be due to a defect which careless usage will develop into a rupture, allowing steam or hot water to escape. Many accidents have resulted from poor management along this line.

Fig. 7 is a valve that is not always satisfactory, at least in my experience; therefore, it is never used in an important place. It is all brass, with a beveled seat and a disk that adjusts itself to the seat. This disk can easily be taken from the stem and, by fitting a wooden handle into it, there is what may be termed "a fighting chance" for regrinding it and thus repairing a leak; but as there is no provision made for grinding the disk, the operation

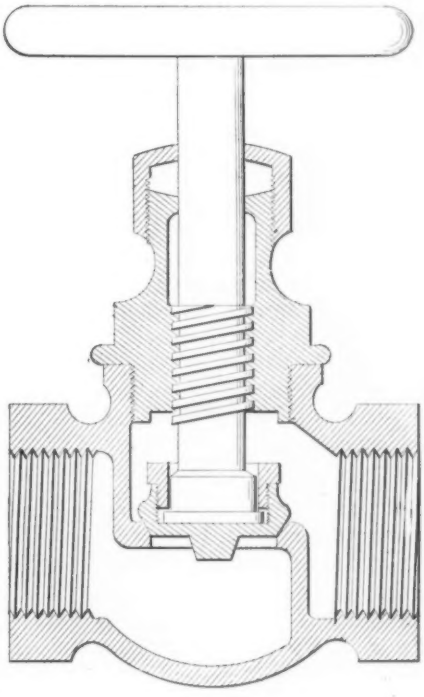


FIG. 7

is tedious and unsatisfactory. As the manufacturers of these valves are not willing to put their names or trademarks on them, it is assumed that they are not guaranteed.

The disk shown in Fig. 8 is loose on the stem in ordinary use, but provision is made for fastening it when it leaks enough to make regrinding necessary. The guide near the lower end of this stem

is held in the position shown by a screw, but when a screwdriver is inserted in the slot and it is given a turn backward, the lug on the lower side of this guide drops into the slot in the disk, where it is fastened by tightening the screw. Of course, it was necessary to remove the bonnet before the screw could be loosened, and by bringing it to the position illustrated the stem and disk can be freely turned for the purpose of regrinding the worn surfaces. As the body of this valve is fitted with an external thread and the bonnet is threaded internally, these threads are not subjected to the direct action of steam, because the joint is made by the surfaces *A* and *B* joining perfectly when the bonnet is screwed into place.

Fig. 9 is another all-metal valve which can be reground at pleasure. The bonnet is removed in the ordinary way, and the disk is then taken off from the stem. A temporary holder is inserted in the disk, then by means of a carpenter's brace the disk can be turned until the regrinding process is complete.

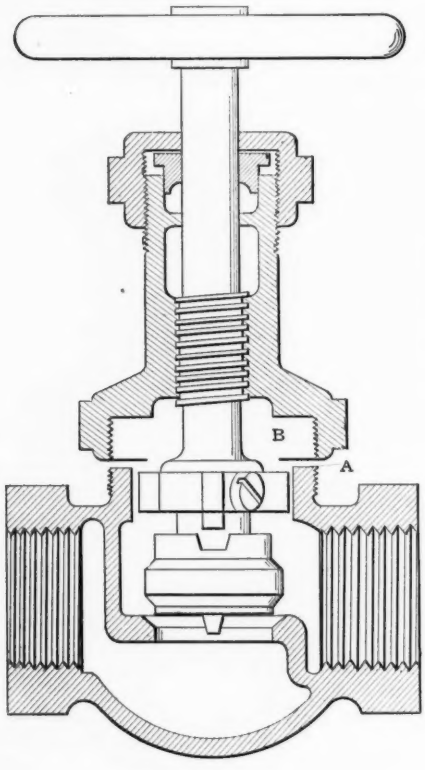


FIG. 8

Special attention is called to the guide forming part of the disk, as it insures true surfaces when efforts are made to eliminate leaks.

Some Peculiar Features

Fig. 10 has peculiar features which are worthy of attention. The bonnet is secured to the body by an internally threaded ring *A*, which resembles a union connection. By unscrewing this ring the trimmings, or, in other words, the entire upper part of the valve can be removed, leaving the body only in place. The disk is now loose on the stem, but by inserting a small wire nail in the hole shown in the former and passing it through a corresponding hole in the latter, as shown in the illustration, the disk is caused to turn with the stem; consequently, the bonnet can be replaced temporarily without screwing the ring down tight, thus forming a guide for the stem, which is turned by the wheel until a perfect joint is secured. It is better to give this wheel not more than one-half revolution and then reverse the motion than always to turn it in one direction, as the grinding material seems to do better work under these conditions. Care must be taken to remove the wire nail and thoroughly clean the internal parts before the trimmings are permanently replaced. When the seat of this valve is badly worn, it can be taken out and a new one inserted.

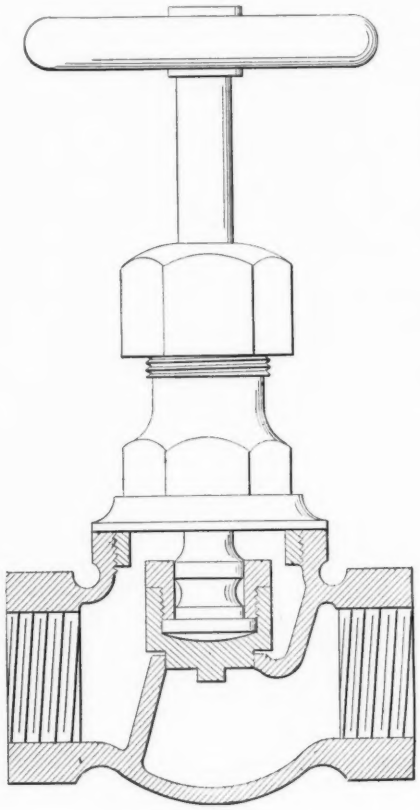


FIG. 9

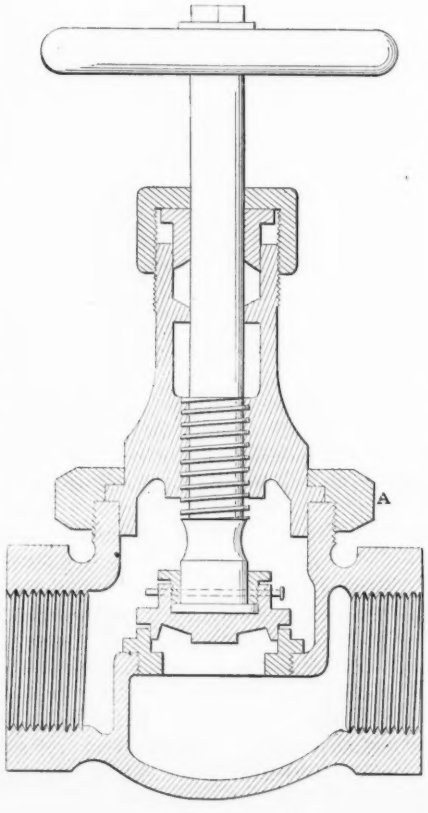


FIG. 10

As this valve is quite different from those previously shown, an external view of it is presented in Fig. 11.

Fig. 12 is fitted with a removable disk holder which cannot come off the stem while in use, but when it is worn out the bonnet is taken off in the usual way, and the stem screwed down as far as it will go, bringing the disk holder clear of the bonnet, thus allowing it to be removed without the use of tools of any kind. A new holder containing a hard-rubber disk is substituted, the stem drawn up and the trimmings put back on the body. Another kind of valve is designed to embody the same principle, but the disk is packed with asbestos which is forced into place under great pressure. Because asbestos is not affected by heat, acids, or oils, these disks should prove durable.

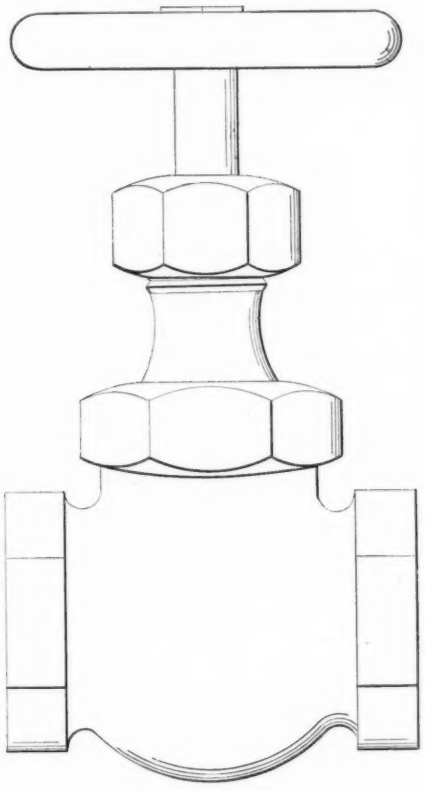


FIG. 11

Fig. 13 is an all-brass valve, except the disk, which is made of copper. The holder is retained on the stem by a slender nut and the disk is kept in the holder by

another nut. When this valve is closed, only the round edge of this disk is in contact with the seat; therefore, it forms a tight joint with comparatively light pressure of the stem. This disk will prove durable when used on lines that carry high-pressure superheated steam. It is possible for this nut to become loosened and finally be turned off by the action of steam passing it swiftly, especially when water is mixed with the steam, which is a condition frequently found in practice during the first few seconds after the valve is opened, and it may exist at other times. To prevent this, put two prick-punch marks in the thread after the nut is screwed firmly into place. These will hold the nut while in service, but will not prevent it from being turned off with a

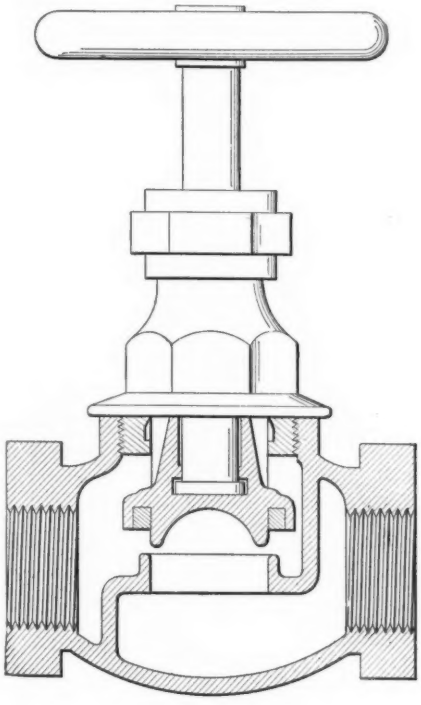


FIG. 12

wrench when a new disk is to be put on.

Fig. 14 shows a brass globe valve fitted with a hard-rubber disk that can be removed at pleasure, as it is held in place by a nut. If the disk does not come out easily with the nut off, hold it in the flame of a gas jet for about one minute. The heat will soften the composition and may be pried out with a small chisel, or a packing hook.

Under common conditions this disk will make a tight joint with no trouble, and will last for a long time. When worn out it can be removed at small expense and with slight trouble. If it lasts only a few days on a steam-pipe line, the pressure is probably too high for that particular kind of disk. Order one that was made to withstand high pressure, and if that fails get one made of babbitt metal. If that does not prove satisfactory, secure a brass disk and grind it to a perfect fit on the seat, as if it were designed for regrinding. While these valves are used extensively, there are many engineers who do not understand their design and operation.

Shape of Disk Important

Another point to be considered is the shape of the disk, for although the external form is round, it does not necessarily follow that it is the same internally. Fig. 15 illustrates a very common design, the object of which is as follows: The nut projects into the disk and corresponds to it, hence one cannot be turned without moving the other. This is a good feature, because the disk becomes fastened to its seat by the action of steam and holds the nut and prevents it from turning off while in use. When the disk is worn out, and a wrench is applied to the nut, the disk must turn also, so no further trouble is found in removing the old disk, provided the wrench can be made to hold on the nut.

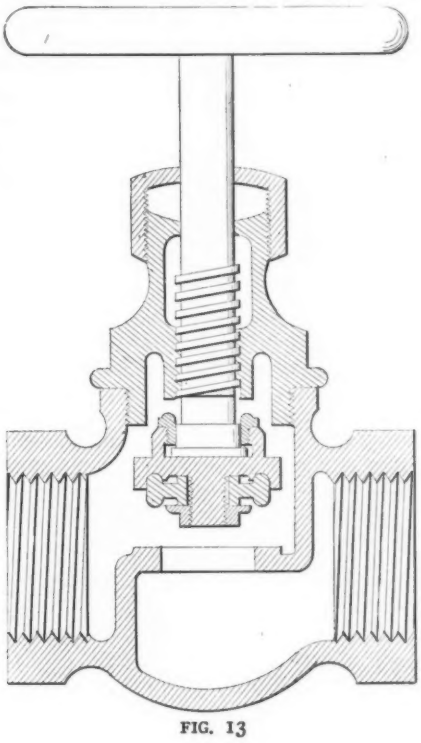


FIG. 13

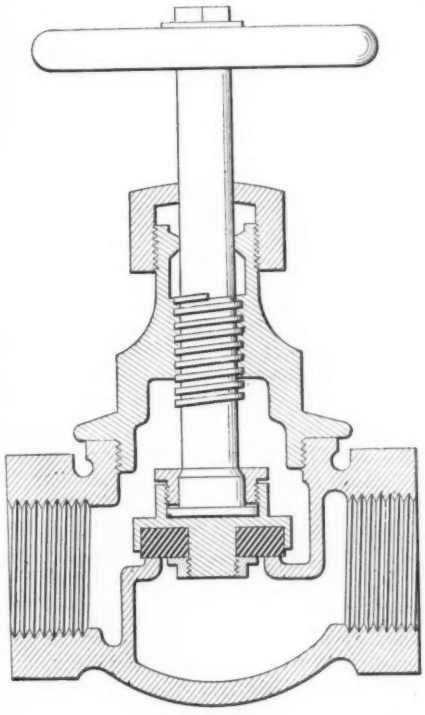


FIG. 14

As a general rule the corners are spoiled by the operation. The wrench slips off, and both nut and disk stay where they were until a Stillson wrench is applied; as the teeth sink into the metal, it cannot slip, but the nut is disfigured or perhaps spoiled by the operation. On this account it is better to file out the flat spots and leave the internal surface a true circle. Thus there is a much better chance of unscrewing the nut without injury, and there is really but little danger of losing it in service if it is fastened according to the suggestions made in connection with Fig. 13. The advantage of having these disks made as shown in Fig. 15 is that the engineer may use them in this condition or not, according to the results of his experience and observation in the matter; but if they were made round internally it would be impracticable to add the flat spots afterward.

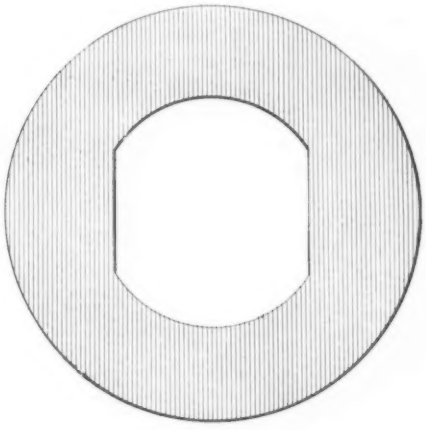


FIG. 15

Fig. 16 is a globe-valve stem with disk holder and fixtures complete. It has nine full threads which are sufficient to hold any pressure that other parts can withstand, but when the valve to which this stem belongs is closed, only a part of them will be meshed into the threads in the bonnet, while the remainder are not in a position to hold anything. A valve that I have just examined has ten threads, but only four are in service when the valve is closed, and in others there may not be more than two. Assuming that it is connected so that pressure acts on the under side of the disk when closed, the maximum stress is on the threads at this time; therefore, one-half of them ought to be where they can assist in holding the disk to its seat.

A globe valve was located with its stem in a horizontal position. After being used for several years the disk holder was quite loose on the stem, and although the seat and disk were in good order, the valve leaked continually. When lost motion at this point was reduced to a very small amount (leaving only enough for correct operation of the valve), by filing the back of the holder until the nut which screws

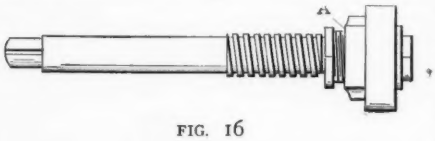


FIG. 16

into it at this point could be turned in almost far enough to grip the stem (see *A*, Fig. 16), the valve was tight when closed. The philosophy of this action is as follows: Lost motion allowed the top of the disk to strike the seat first, and further action of the screw was not sufficient to make it bear evenly; consequently it leaked. When this unnecessary lost motion was taken up, the disk rested against the seat squarely and made a tight joint.

The manufacturers of many of the globe valves now in the market claim that when they are opened wide it is possible to pack them at pleasure. This is undoubtedly correct when applied to the valves actually guaranteed, but it is not wise to apply it to all valves found in a steam plant without knowing their design. To test a valve for this feature, open it wide, apply the packing pliers illustrated in Fig. 3 and cautiously unscrew the packing nut. If steam escapes it shows that this valve cannot be packed under pressure, but the nut can be forced down into its proper place by the pliers, and the application of a wrench will soon stop the leak of steam. Let the matter rest until pressure can be removed from the line, then pack the valve in a workmanlike manner.

The Oppressiveness of Erudition

"The trouble with me is that I know too darn much," drawled the puzzle editor as the chief passed his desk.

"How so?"

"Didn't you ever notice that the less a man knows about a thing the quicker he can give you an answer about it? For instance, here is a fellow who wants to know what is the difference between the gage pressure and the absolute pressure. I was on the point of telling him 15 pounds. If your gage pressure is 75 pounds, the absolute pressure is 75 + 15 = 90 pounds. That is good enough for most cases, and more exact than men ordinarily read gages or than gages usually are, but I happened to think that that fellow may use Kent's table, where the gage pressures are all given with an 0.3 after them and the gage pressure corresponding with 90 absolute is 75.3. So I start in to tell him to add 14.7 to the gage pressure to get the absolute, and then it struck me that this is only right if the pressure of the atmosphere is 14.7 pounds, and if it happens to be so it is an accident. I can tell him to add the pressure of the atmosphere to his gage pressure, but how is he going to get the pressure of the atmosphere? If he takes it by the barometer, it will be right for that place and time, but may not be right for another place or another time or for the case that he is working on. And then he gets it in inches of mercury and he has to use it in pounds per square inch. No two authorities agree as to the weight of a cubic inch of mercury and it is dollars to doughnuts that he wouldn't have pure mercury in his barometer, and the weight per cubic inch varies with the temperature, which he would not know, and then again a cubic inch of pure mercury at the same temperature weighs less at the equator than it does at the poles on account of the centrifugal force, so that the latitude comes in. Gee, I could write a book about it. If I only knew half as much my work would be twice as easy."

Steam Boiler Water Gages

By H. A. Jahnke

The writer has noticed quite often that the water gage and try cocks on a boiler do not receive the attention they should get. A great many firemen, and some engineers who do their own firing, blow the dirty water out of the water column and gage glass perhaps once or twice a week, which is bad practice.

The water column and gage glass should be blown out three or four times a day, or as often as is necessary to keep the water-column and gage-glass connections free from mud and scale. If there are valves in the water-column connections the steam valve should be closed and the valve in the water connection and drain valves on the bottom of the water column opened for a short time, in order to blow out of the lower connection all obstruction which may have lodged there. Then the valve in the lower connection should be closed and the valve in the top connection opened for awhile, after which the drain valve should be closed and the valves in both connections opened wide.

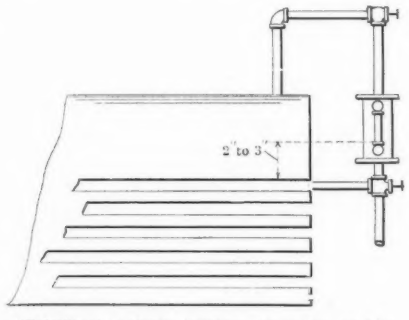
Water columns and gage glasses are often connected up in such a way that as soon as there is no water shown in the gage glass the top row of tubes in a horizontal return-tubular boiler are dry. The proper way to arrange the water column and gage glass is to locate the gage glass fairly high, then as long as water shows in the glass there will be at least 2 to 3 inches over the top row of tubes, as shown in the accompanying sketch.

It is a good plan, when an engineer takes charge of a new plant, for him to find out at the first opportunity how the water column and gage glass are set, in order to determine at what point it is safe to carry the water and to fix the low and high points. He should also find out what condition the water-column connections are in and know if they are clear of obstructions.

Some Causes of Gage Glasses Breaking

Gage glasses often break because the water-gage valves are not in line with each other and when the packing nuts are screwed up tight they bind the glass, causing it to break. The hole in the packing nut may be too small for the diameter of the glass and prevent the glass from expanding. When it gets hot, the hole should be enlarged a little with a file. Air striking the glass in cold weather when a door or window is opened will cause unequal expansion of the glass, which will break it. Where the cold air cannot be prevented I have found that the "Gilbert" gage-glass ring is a good thing to use for the packing nuts of the gage glass.

If the packing rings of a gage glass are in use for a long time they get too hard and there is no cushion to prevent the strain on the glass and it will break. This trouble can be avoided by renewing the packing rings frequently. In steam plants which are in operation only during the daytime it is good practice to close the gage-glass valves at night after shutting down, as the glass is liable to break during the night, and if there is no watchman in the plant there will be trouble in the morning. Some years ago, when I entered the boiler room one morning the room was full of steam. Looking for the cause, I found that one of the gage glasses had broken during the night, and that it must have happened in the early part of the night because most of the steam had been blown out of the boiler and no water could be seen in the gage glass. By trying the drain cock at the water gage it was found there was water up to this point and there still was water over the top row of tubes. Cold water had to be run into the boiler in order to bring water into the glass again. All the pipe covering in the boiler room on the steam pipes was dripping wet. Had the gage-glass valves been closed the night before all this trouble would have been avoided.



SHOWING PROPER HIGHT OF GAGE GLASS

Classification and Uses of Wrenches

A Treatise on the Proper Names, Uses and Abuses of Wrenches in Everyday Practice; Notes on the Screwdriver and a Few General Kinks

BY HUBERT E. COLLINS

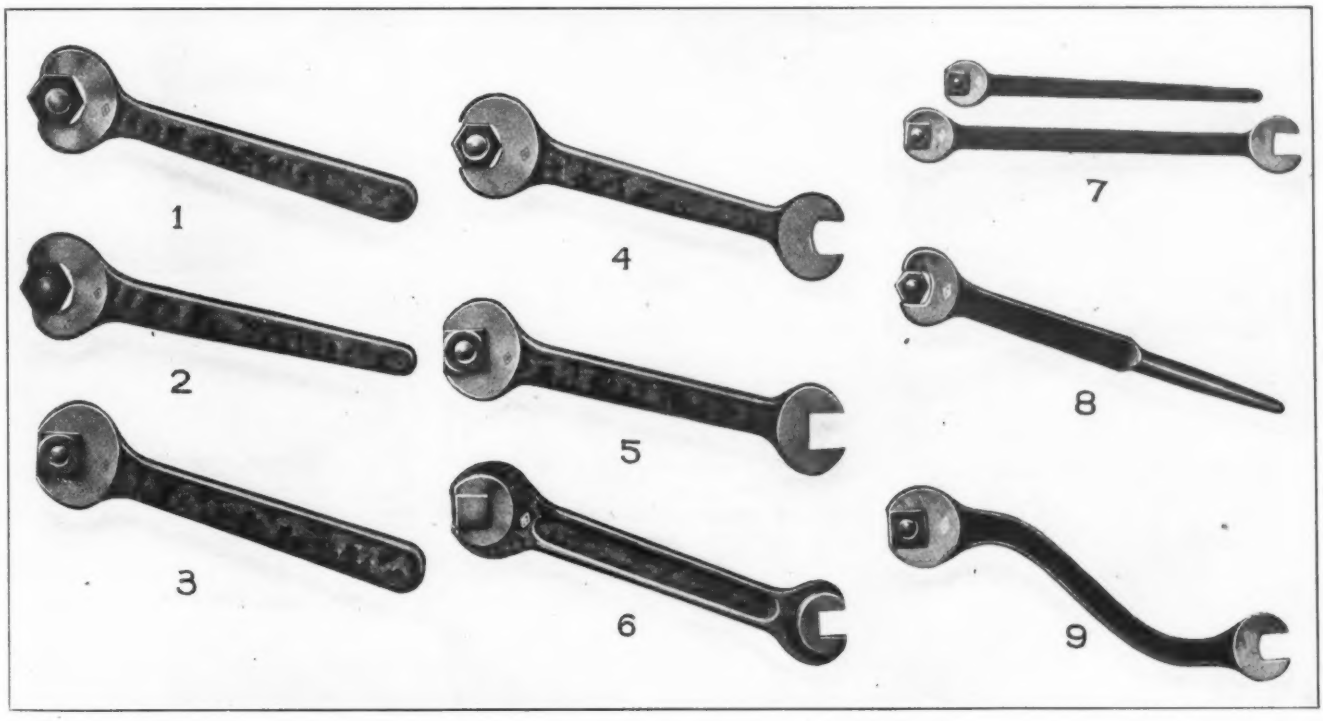
Good machinists understand the proper use of wrenches of every kind and description, and it is only natural that they should, as it is a part of their training. Among engineers with no mechanical training, over 50 per cent. do not know how to properly handle wrenches, and the percentage among steamfitters, firemen, oilers, dynamo attendants and the help generally is nearer 100 than 50. Not only are they ignorant of the proper uses of wrenches, but very few can call them by their proper names. These statements are made after a period of 17 years' observation, and it is believed that they cannot be successfully contradicted.

It is of great importance in the saving of time around a plant to have the men all trained in the use of wrenches, although to many it may seem a trivial matter. In many plants it will be found that there are no wrenches to fit certain nuts or bolt heads. Upon investigation it will be found that when the engine, dynamo, pump, or whatever piece of machinery it is, was installed, a wrench was supplied for the place now requiring its use, but it is either lost or more frequently, through ignorance, it is spoiled so that it cannot be used. For these reasons, it is believed that a talk on this subject should be of value in the engine room, and more especially if proper consideration is given to it. When the reader considers the various types of wrenches here illustrated and the proper uses here explained, it is believed that if he has not the wrench wanted, he can find some way to use what he has or get an idea of how to make the proper wrench for his service.

Classification

Many times in calling for a wrench, the one asked for is not brought, because the man sent for it does not know the names of wrenches and cannot associate in his mind a wrench to fit the name given it, or *vice versa*. This is due to a lack of familiarity with the different types of wrenches and their names. For the purpose of classifying and properly naming, the accompanying illustrations of wrenches are given. Figs. 1 to 9, inclusive, are types of wrenches commonly called solid, open-ended wrenches. They are drop-forged and case-hardened, and are in general use. Fig. 10 is a cut of a special solid, open-ended wrench, as is also the one shown in Fig. 11. Figs. 12 and 13 are types of standard make box wrenches. Figs. 14, 15 and 16 are types of socket wrenches, and Fig. 17 is two views of a socket wrench made for heavy work. Fig. 18 is a box wrench for heavy work. Figs. 19, 20 and 21 are types of spanner wrenches, Fig. 19 being a pin spanner, Fig. 20 a hook spanner, and Fig. 21 a face spanner.

Figs. 22, 23, 24, 25, 26 and 27 are types of strap wrenches, Fig. 28 is the common monkey wrench and Figs. 29, 30 and 31 are types of pipe or Stillson wrenches. Figs. 32 and 33 are types of alligator pipe wrenches, and Fig. 34 is a pair of pipe tongs. Figs. 35 and 36 are two views of a chain pipe wrench or chain wrench, and Fig. 37 is a type of key wrench.

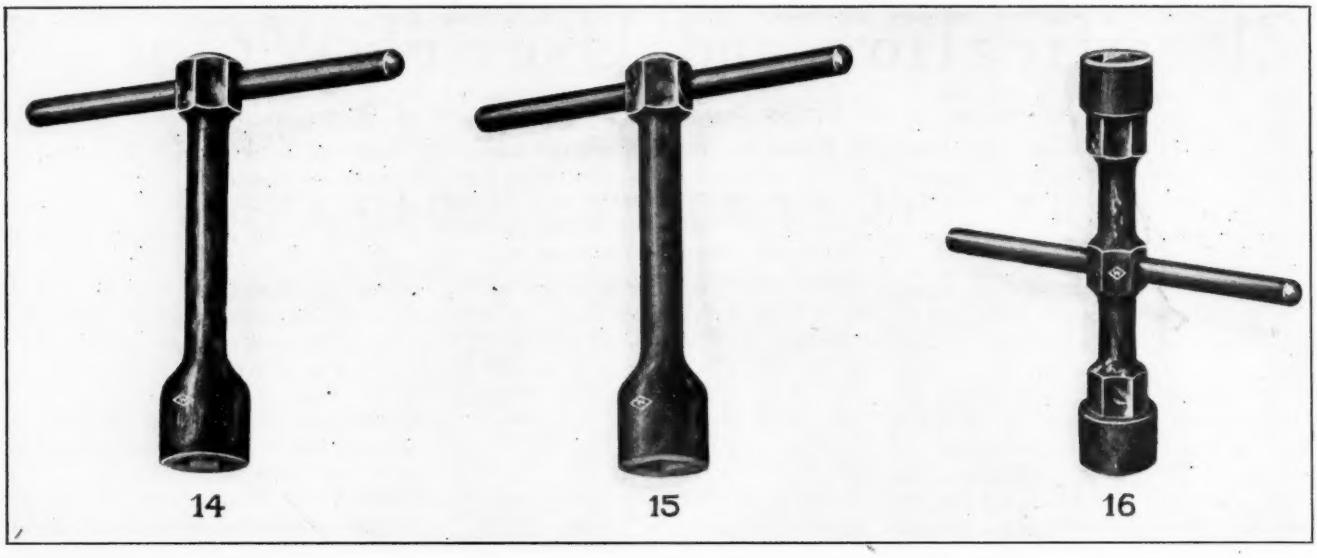


SOLID OPEN-ENDED WRENCHES

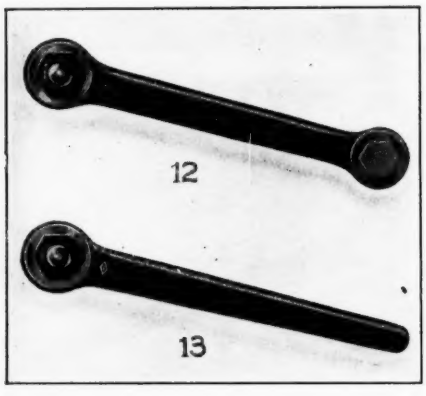
The open-end and box wrenches here illustrated are either straight or angle wrenches. Fig. 7 shows two types of straight wrenches, and Figs. 1, 2, 3, 4, 5, 6, 8, 9, 12 and 13 are angle wrenches. These open-end, box and socket wrenches are also single or double headed, as shown.

The Various Uses of Wrenches

All types of angle wrenches are for use where a straight or monkey wrench will not reach the next hold on a nut or bolt



TYPES OF SOCKET WRENCH



BOX WRENCHES OF STANDARD MAKE

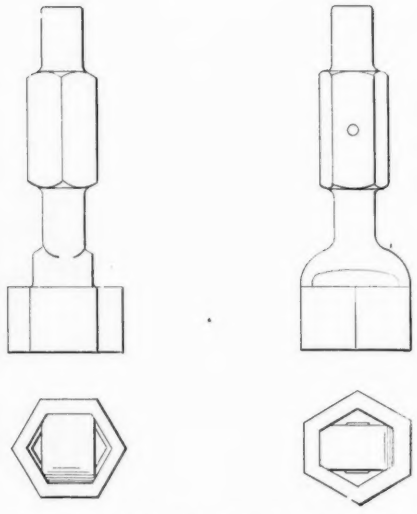
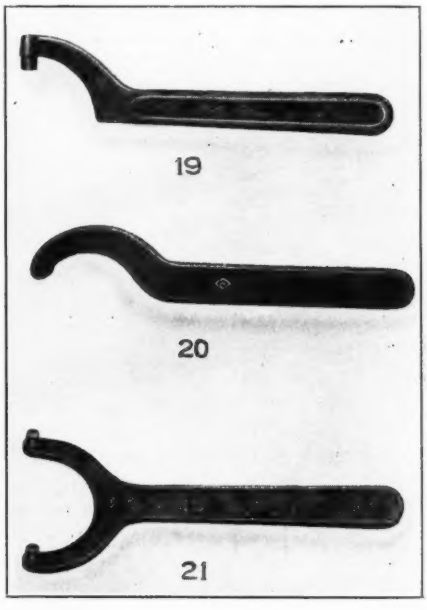


FIG. 17. SOCKET WRENCHES FOR HEAVY WORK



PIN, HOOK AND FACE SPANNERS

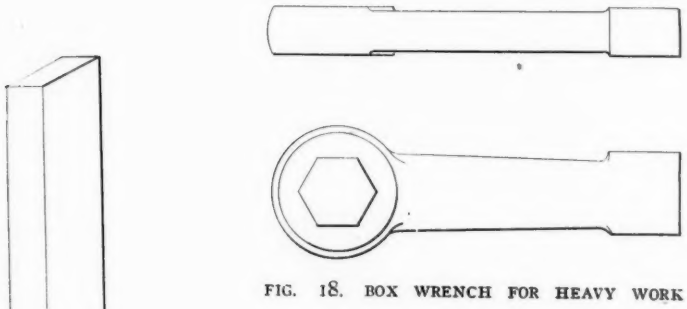
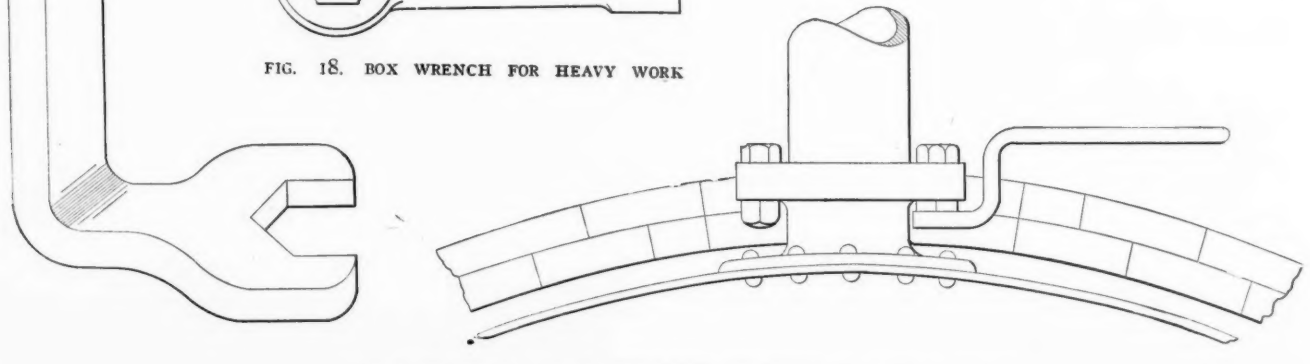


FIG. 18. BOX WRENCH FOR HEAVY WORK



FIGS. 10 AND 11. SOLID OPEN-ENDED WRENCHES OF SPECIAL DESIGN

head after starting to set up on or slack the nut. This type of wrench is needed in every plant in places such as the nuts of a cylinder head, flange bolts, engine frames, etc. The angle is the amount the wrench head is offset from the center line of the wrench handle, as shown in Fig. 38, where *A* is the head of an angle wrench and *B* the head of a straight wrench. The line *C D* is the common center line of the two wrench handles. It will be seen that the line *E F* through the head of *A* is offset 30 degrees from *C D*. Many degrees of angle for this offset have been used by manufacturers, but the angles are mostly 15, 30 and 60 degrees for hexagon nuts, and 45 degrees for square nuts.

As angle wrenches are to be used in tight places or close corners, the object is to turn the nut or bolt head just far enough so that the next flats can be caught by the wrench. A hexagon nut must be turned 60 degrees in order that a wrench may catch the next flats, while the wrench remains or is brought back to the first position to start again in the operation of setting up or slacking off. A square nut needs to turn 90 degrees to present a new set of flats to the jaws of a wrench. If there is room enough to turn a hexagon nut 60 degrees or a square nut 90 degrees, a straight open-ended or monkey wrench may serve the purpose as well as an angle wrench, but where closer quarters do not allow of this much play of the wrench, the latter must be offset just enough for it to take hold twice on the same side of the nut in one turning. Then the required pitch or angle

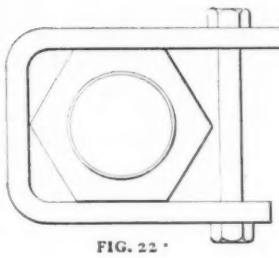


FIG. 22.

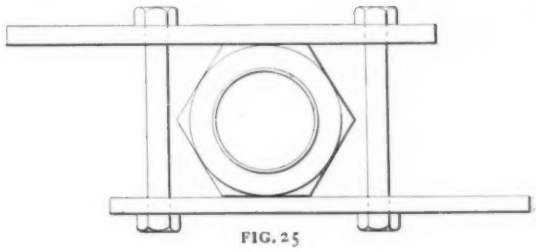


FIG. 25

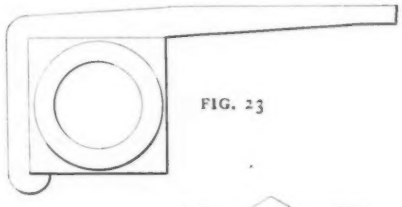


FIG. 23

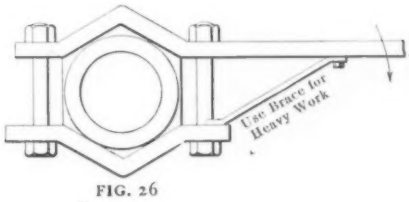


FIG. 26

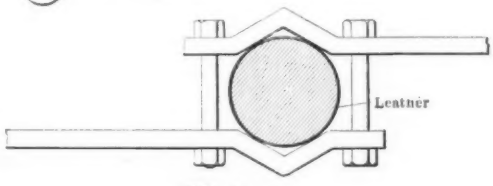


FIG. 24

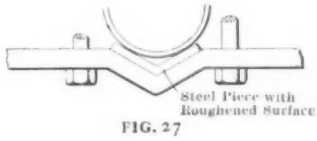


FIG. 27

STRAP WRENCHES

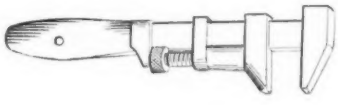


FIG. 28. MONKEY WRENCH

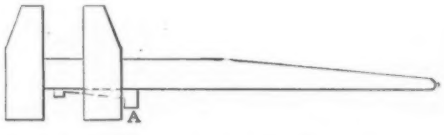


FIG. 37. TYPE OF KEY WRENCH

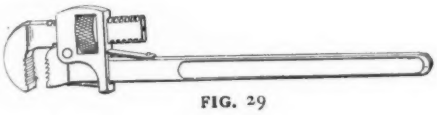


FIG. 29

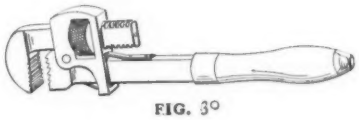


FIG. 30

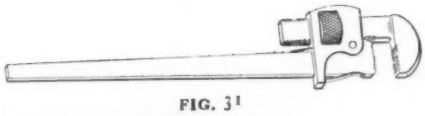


FIG. 31

PIPE OR STILLSON WRENCHES

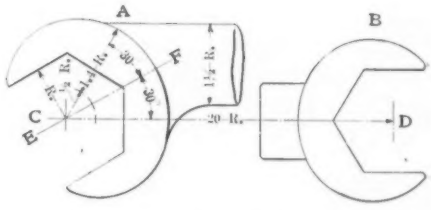


FIG. 38. WRENCH OFFSET 30 DEGREES

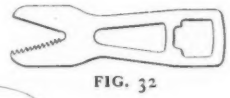


FIG. 32

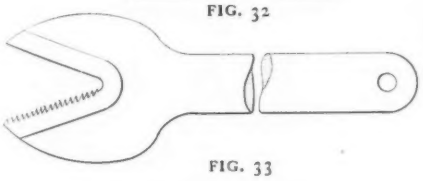
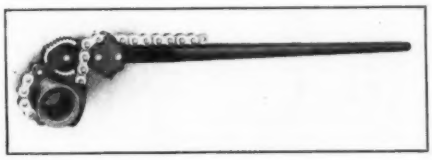
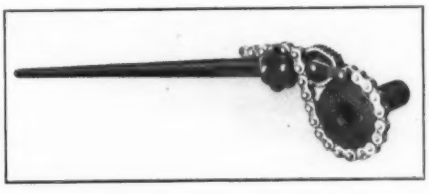


FIG. 33

ALLIGATOR PIPE WRENCHES

FIG. 34. PIPE TONGS





FIGS. 35 AND 36. APPLICATIONS OF PIPE WRENCH TO DIFFICULT JOB

of the wrench will be one-fourth of the amount required to turn the sides around. For a hexagon nut this would be one-fourth of 60 or 15 degrees, and for a square nut one-fourth of 90 or an offset of 22½ degrees.

Referring to Fig. 39, it will be seen that with the wrench starting at *A* and moved to *B*, the nut will be turned 30 degrees, and by turning the wrench over and bringing it back to *A*, it will engage the nut, and when moved over to *B* for the second time, the nut will have been turned 60 degrees. By again turning the wrench and bringing it to *A*, the operation can be repeated and so continued until the work is finished. The same thing applies to the turning of a square nut with a wrench offset 22½ degrees. For this reason, when having angle

wrenches made to order, do not allow them to be offset more than these amounts.

Box wrenches, shown in Figs. 12, 13 and 18, whether angle or straight, have

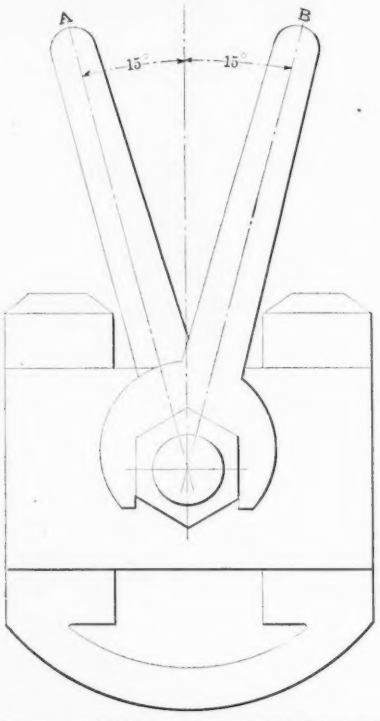


FIG. 39. WRENCH WITH 15-DEGREE OFFSET

many advantages over the open-ended wrench whenever it is possible to use them. The head, fitting all sides of the nut, brings less strain on it, and fitting closer allows it to hold the nut with but little possibility of slipping.

Open-ended wrenches with long leverage, such as those in Figs. 7, 8 and 9, are used on iron work, pipe flanges and other construction work. A good style of wrench for pipe flanges is that shown in Fig. 8. The handle of this wrench can first be used as a drift to bring the bolt holes in line. The wrench shown in Fig. 9 is called an S-wrench because of its shape.

Socket wrenches, such as are shown in Figs. 14, 15 and 16, are used mostly where the bolt heads or nuts are in a recess, as in the case of piston-follower bolts or the screw heads on a universal chuck for a lathe. When socket wrenches are made as in Fig. 17, they are used on the larger sizes of bolt heads or nuts.

Spanner wrenches, like those in Figs. 19 and 20, are used largely on stuffing-box nuts for pumps and small engines. The face spanner, Fig. 21, is a special wrench. One use for it is shown in Fig. 40, where an eccentric, which needs turning around the shaft, is situated between the bearing and flywheel of an engine so close that no other method of grasping it will do. This is only one illustration of its use.

The various types of strap wrenches here shown are to be made for specific purposes, and Figs. 22 to 27, inclusive, offer many suggestions as to type of wrench and places for their use. In Fig. 28 we recognize the familiar monkey wrench, whose uses are many and varied. Owing to the fact that it is easily adjustable to any size of bolt head or nut within its range, it is used more than any other wrench, except for pipe work and in close places. Fig. 37 shows a type of key wrench which also has a wide use. One jaw is slotted to slip over the handle and hold a key *A*. By slacking on the key, the jaws can be adjusted to any size and the key set up so as to hold the jaw rigid.

Figs. 29, 30 and 31 are Stillson or pipe wrenches to be used on pipe and pipe fittings and in some instances on studs. The alligator wrenches in Figs. 32 and 33 are for use on pipe and fittings also, but not for as heavy work as stillsons. The pipe tongs, shown in Fig. 34, are for use on pipe, and more especially on work where there is not much space to operate in. For illustration, in making up pipe coils with manifold headers, the space is so small between the pipes while they are being screwed into place, that a Stillson wrench cannot be used, as the head is too thick. In such an event, the pipe tongs must be called into service. Figs. 35 and 36 show two views of a chain wrench illustrating its application to a difficult job. This style of wrench can be had in small sizes to do the work of a stillson wrench, and with success, but they are used mostly on large pipes and fittings.

TABLE 1. SIZES FOR TAPER-HANDLED ENGINEERS' WRENCHES.

For U. S. Standard Nut; Size Bolt.	Opening, Milled.	Extreme Length.	Thickness, Head.
¼	½	3¾	¼
5/16	9/16	4¼	5/16
⅜	11/16	5⅛	⅜
7/16	25/32	6½	13/32
½	⅞	7½	7/16
9/16	31/32	8¾	½
⅝	1 1/16	9½	9/16
¾	1¼	11⅛	⅝
⅞	1 7/16	13	23/32
1	1⅝	14¾	¾
1⅛	1 13/16	16½	27/32
1¼	2	18½	29/32
1⅜	2 3/16	20	1
1½	2⅜	22	1 1/16
1⅝	2 9/16	24	1⅛
1¾	2¾	25½	1 3/16
1⅞	2 15/16	25½	1 3/16
2	3⅛	29½	1⅜
2¼	3½	33	1 7/16
2½	3¾	37	1½
2¾	4¼	37	1½
3	4½	44	1⅝
3½	5⅛	44	1⅝
4	6½	59	2⅝
4½	6¾	59	2⅝

TABLE 2. SIZES OF DOUBLE-HEADED ENGINEERS' WRENCHES. (FIG. 7.)

For U. S. Standard Nuts; Size Bolts.	Openings, Milled.	Extreme Length.	Thickness, Heads.
¼ & 5/16	⅜ & 13/32	3¼	13/32 & 7/32
⅜ & 7/16	7/16 & ½	4	15/32 & ¼
7/16 & ½	½ & 9/16	4	17/32 & ¼
½ & 9/16	9/16 & 5/8	4⅞	19/32 & 5/16
9/16 & ⅝	5/8 & 11/16	4⅞	21/32 & 5/16
⅝ & ¾	¾ & ⅞	5¼	¾ & 5/16
¾ & ⅞	⅞ & 1	5¼	25/32 & ⅜
⅞ & 1	1 & 1 1/16	5¾	13/16 & ⅜
1 & 1⅛	1 1/16 & 1⅛	6¼	27/32 & 7/16
1⅛ & 1¼	1⅛ & 1 3/16	6¼	29/32 & 7/16
1¼ & 1⅜	1 3/16 & 1¼	6¾	31/32 & 7/16
1⅜ & 1½	1¼ & 1⅜	7¼	1 & ½
1½ & 1⅝	1⅜ & 1½	7¼	1 1/32 & ½
1⅝ & 1¾	1½ & 1⅝	8¼	1 1/16 & 9/16
1¾ & 1⅞	1⅝ & 1¾	8¼	1 3/32 & 9/16
1⅞ & 2	1¾ & 1 15/16	9¼	1 5/32 & 9/16
2 & 2¼	1 15/16 & 2 3/16	9¼	1 7/32 & 9/16
2¼ & 2½	2 3/16 & 2 7/16	11½	1 9/32 & ⅝
2½ & 2¾	2 7/16 & 2 11/16	11½	1 11/32 & ⅝
2¾ & 3	2 11/16 & 2 15/16	13½	1 13/32 & ⅝
3 & 3¼	2 15/16 & 3 3/16	13½	1 15/32 & ⅝
3¼ & 3½	3 3/16 & 3 7/16	15½	1 17/32 & ⅝
3½ & 3¾	3 7/16 & 3 11/16	15½	1 19/32 & ⅝
3¾ & 4	3 11/16 & 3 15/16	17	1 21/32 & ⅝
4 & 4¼	3 15/16 & 4 3/16	17	1 23/32 & ⅝
4¼ & 4½	4 3/16 & 4 7/16	19	1 25/32 & ⅝
4½ & 4¾	4 7/16 & 4 11/16	19	1 27/32 & ⅝
4¾ & 5	4 11/16 & 4 15/16	21	1 29/32 & ⅝
5 & 5¼	4 15/16 & 5 3/16	21	1 31/32 & ⅝
5¼ & 5½	5 3/16 & 5 7/16	23	2 1/32 & ⅝
5½ & 5¾	5 7/16 & 5 11/16	23	2 3/32 & ⅝
5¾ & 6	5 11/16 & 5 15/16	25	2 5/32 & ⅝
6 & 6¼	5 15/16 & 6 3/16	25	2 7/32 & ⅝
6¼ & 6½	6 3/16 & 6 7/16	27	2 9/32 & ⅝
6½ & 6¾	6 7/16 & 6 11/16	27	2 11/32 & ⅝
6¾ & 7	6 11/16 & 6 15/16	27	2 13/32 & ⅝
7 & 7¼	6 15/16 & 7 3/16	30½	2 15/32 & ⅝
7¼ & 7½	7 3/16 & 7 7/16	30½	2 17/32 & ⅝
7½ & 7¾	7 7/16 & 7 11/16	30½	2 19/32 & ⅝
7¾ & 8	7 11/16 & 7 15/16	34	2 21/32 & ⅝
8 & 8¼	7 15/16 & 8 3/16	34	2 23/32 & ⅝
8¼ & 8½	8 3/16 & 8 7/16	34	2 25/32 & ⅝
8½ & 8¾	8 7/16 & 8 11/16	39	2 27/32 & ⅝
8¾ & 9	8 11/16 & 8 15/16	39	2 29/32 & ⅝
9 & 9¼	8 15/16 & 9 3/16	39	2 31/32 & ⅝
9¼ & 9½	9 3/16 & 9 7/16	39	3 1/32 & ⅝
9½ & 9¾	9 7/16 & 9 11/16	46	3 3/32 & ⅝
9¾ & 10	9 11/16 & 9 15/16	46	3 5/32 & ⅝
10 & 10¼	9 15/16 & 10 3/16	46	3 7/32 & ⅝
10¼ & 10½	10 3/16 & 10 7/16	46	3 9/32 & ⅝

Figs. 29, 30 and 31 are Stillson or pipe wrenches to be used on pipe and pipe fittings and in some instances on studs. The alligator wrenches in Figs. 32 and 33 are for use on pipe and fittings also, but not for as heavy work as stillsons. The pipe tongs, shown in Fig. 34, are for use on pipe, and more especially on work where there is not much space to operate in. For illustration, in making up pipe coils with manifold headers, the space is so small between the pipes while they are being screwed into place, that a Stillson wrench cannot be used, as the head is too thick. In such an event, the pipe tongs must be called into service. Figs. 35 and 36 show two views of a chain wrench illustrating its application to a difficult job. This style of wrench can be had in small sizes to do the work of a stillson wrench, and with success, but they are used mostly on large pipes and fittings.

Proportions of Wrenches

Manufactured wrenches, whether finished or unfinished in reputable factories, are so proportioned that they will stand all strain brought to bear on them, or that should be put upon the stud or bolt they are used on. The manufacturers have adopted a standard table of proportions in most cases, and where sizes vary from these here given, the variations are in proportion. For example, in the tables given, a wrench is proportioned with a certain thickness of head for a given length of handle or lever. Where tables show a thinner head, the length of handle is shorter. The size of opening in the jaws for the nut or bolt head is the same in all makes of wrenches for nuts and cap-bolt heads. The wrenches for standard finished nuts are larger in the openings than for cap bolts.

For comparison of sizes refer to Tables 1, 2 and 3. Table 1 gives the sizes for engineers' wrenches, single head, as illustrated in Fig. 2; Table 2 the sizes for engineers' wrenches, double head, as illustrated in Fig. 7, and Table 3 the sizes for cap-bolt wrenches, single head, the appearance of which is the same as Fig. 2. Table 4 gives the principal dimen-

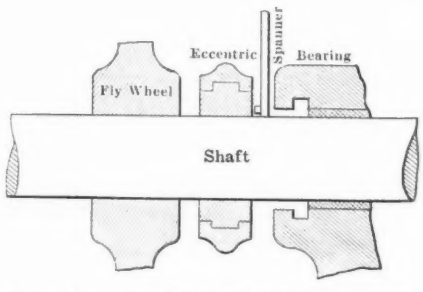


FIG. 40. FACE SPANNER TURNING ECCENTRIC ON SHAFT

sions of socket wrenches, such as are shown in Fig. 16, and is also of use when recesses for bolt heads are to be provided for in castings.

Where wrenches are not easily obtainable and a blacksmith can be found to make some, these tables are of value for the proper proportioning of a wrench for strength and for a fit to standard sized nuts and bolts. For additional information regarding other dimensions of wrenches, refer to Table 5, in which it will be noted that the heads are thinner and the levers shorter than in Tables 1 and 2, but are of the same proportion.

Size of Wrench with Reference to Size of Nut

When the size of a solid wrench is spoken of, the reference is made to the wrench which will fit a nut or head for the given size of bolt. For example, if a

TABLE 3. CAP-BOLT WRENCHES, SINGLE HEAD.

For Hexagon Head Cap-screws; Diameter Screws.	Openings, Milled.	Extreme Length.	Thickness, Head.
1/4	5/16	2 1/2	1/4
5/16	3/8	2 7/8	5/16
3/8	7/16	3 1/2	3/8
7/16	1/2	4 1/4	7/16
1/2	9/16	5	1/2
9/16	5/8	5 3/4	9/16
5/8	11/16	6 1/2	5/8
11/16	3/4	7 1/4	11/16
3/4	7/8	8	3/4
7/8	1	9 1/2	7/8
1	1 1/8	11	1
1 1/8	1 1/4	12 1/2	1 1/8
1 1/4	1 3/8	14	1 1/8
1 3/8	1 1/2	15 1/2	1 1/8
1 1/2	1 5/8	17	1 1/8

TABLE 4. DOUBLE-HEADED SOCKET WRENCHES, HEXAGON HEADS. (FIG. 16.)

Hexagon Openings. For U. S. Standard Nuts; Size Bolts.	Hexagon Openings. For Cap Screws; Diameter Screws.	Hexagon Openings. Short Diameter Broached Openings.	Extreme Length.	Diameter of Head.	Diam. of Shank.	Hexagon Parts of Shank Same Size as U. S. Nut; for Size Bolt.	Size of Pin Handle. Diameter.	Size of Pin Handle. Length.
1/4 & 5/16		21/64 & 37/64	4 1/2	9/16 & 11/16	3/8			
3/8 & 7/16		41/64 & 57/64	6 1/2	3/4 & 7/8	1/2	1/4	7/32	4 1/2
1/2 & 9/16		27/32 & 33/64				5/16	9/32	5 1/2
	3/16 & 1/4	29/64 & 35/64						
	5/16 & 3/8	31/64 & 37/64	6 1/2	3/4 & 7/8	1/2	5/16	9/32	5 1/2
5/8 & 11/16		33/64 & 39/64						
3/4 & 13/16		35/64 & 41/64						
	1/4 & 3/8	37/64 & 43/64						
	5/16 & 7/16	39/64 & 45/64						
7/8 & 15/16		41/64 & 47/64	7 1/2	1 1/8 & 1 5/32	3/4	1/2	13/32	7
1 & 1 1/16		43/64 & 49/64						
	7/16 & 1/2	45/64 & 51/64						
1 1/8 & 1 3/16		47/64 & 53/64						
	1/2 & 9/16	49/64 & 55/64						
	9/16 & 5/8	51/64 & 57/64						
1 1/4 & 1 5/16		53/64 & 59/64						
	5/8 & 11/16	55/64 & 61/64						
	11/16 & 3/4	57/64 & 63/64						
1 3/8 & 1 7/16		59/64 & 1 1/64	9 1/2	1 1/2 & 1 31/32	3/4	3/4	1/2	8 1/2
1 1/2 & 1 9/16		61/64 & 1 3/64						
	3/4 & 13/16	63/64 & 1 5/64						
	13/16 & 7/8	1 1/64 & 1 7/64						
	7/8 & 15/16	1 3/64 & 1 9/64						
	15/16 & 1	1 5/64 & 1 11/64						
1 5/8 & 1 11/16		1 7/64 & 1 13/64						
1 3/4 & 1 13/16		1 9/64 & 1 15/64						
	1 & 1 1/8	1 11/64 & 1 17/64						
1 7/8 & 1 15/16		1 13/64 & 1 19/64						
2 & 2 1/16		1 15/64 & 1 21/64	11	1 7/8 & 2 3/16	1	7/8	11/16	10
	1 1/8 & 1 1/4	1 17/64 & 1 23/64						
	1 1/4 & 1 3/8	1 19/64 & 1 25/64						
2 1/8 & 2 3/16		1 21/64 & 1 27/64						
2 1/4 & 2 5/16		1 23/64 & 1 29/64						
	1 3/8 & 1 1/2	1 25/64 & 1 31/64						
2 3/8 & 2 7/16		1 27/64 & 1 33/64						
2 1/2 & 2 5/8		1 29/64 & 1 35/64	13 1/2	2 1/2 & 2 13/16	1 1/4	1 1/4	7/8	11 1/2
2 3/4 & 2 7/8		1 31/64 & 1 37/64						
3 & 3 1/8		1 33/64 & 1 39/64						
3 1/4 & 3 3/8		1 35/64 & 1 41/64						
3 1/2 & 3 5/8		1 37/64 & 1 43/64						
3 3/4 & 3 7/8		1 39/64 & 1 45/64						
4 & 4 1/8		1 41/64 & 1 47/64						
4 1/4 & 4 3/8		1 43/64 & 1 49/64						
4 1/2 & 4 5/8		1 45/64 & 1 51/64						
4 3/4 & 4 7/8		1 47/64 & 1 53/64						
5 & 5 1/8		1 49/64 & 1 55/64						
5 1/4 & 5 3/8		1 51/64 & 1 57/64						
5 1/2 & 5 5/8		1 53/64 & 1 59/64						
5 3/4 & 5 7/8		1 55/64 & 2 1/64						
6 & 6 1/8		1 57/64 & 2 3/64						

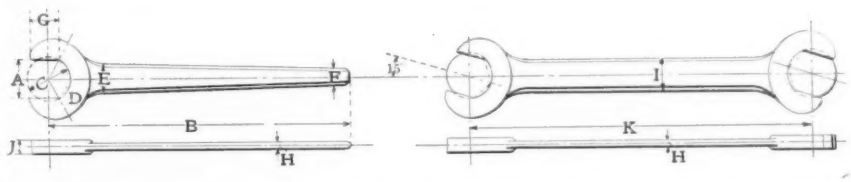


TABLE 5. APPROVED PROPORTIONS OF WRENCHES.

Bolt	A	B	C	D	E	F	G	H	I	J	K
1/4	1/2	3 1/2	37/64	1/4	3/8	5/16	5/16	5/32	7/16	7/16	4
5/16	19/32	4 1/4	9/16	5/16	7/16	3/8	3/8	3/16	1/2	1/4	5
3/8	11/16	4 1/2	41/64	3/8	1/2	7/16	7/16	1/4	19/32	5/16	5 1/2
7/16	25/32	5 1/2	9/16	7/16	9/16	1/2	1/2	5/16	21/32	3/8	6 1/2
1/2	7/8	6	1	1/2	5/8	9/16	9/16	3/8	3/4	7/16	7
9/16	31/32	6 3/4	1 1/32	9/16	11/16	5/8	5/8	7/16	13/16	1/2	8
5/8	1 1/16	7 1/2	1 3/32	5/8	3/4	11/16	11/16	1/2	7/8	9/16	8 1/2
3/4	1 1/4	8 1/2	1 7/16	3/4	7/8	13/16	13/16	9/16	1	1/2	10
7/8	1 7/16	10	1 11/32	7/8	1	15/16	15/16	5/8	1 1/32	19/32	11 1/2
1	1 5/8	11 1/2	1 1/2	1	1 1/16	1 1/16	1 1/16	11/16	1 1/8	5/8	13
1 1/8	1 13/16	12 1/2	2 3/32	1 1/16	1 1/8	1 1/8	1 1/8	3/4	1 3/16	11/16	14 1/2
1 1/4	2	14	2 5/16	1 1/8	1 3/16	1 3/16	1 3/16	13/16	1 5/16	3/4	16
1 3/8	2 3/16	15 1/2	2 1/2	1 3/16	1 1/4	1 1/4	1 1/4	7/8	1 7/16	13/16	17 1/2
1 1/2	2 3/8	16 1/2	2 3/4	1 1/4	1 5/16	1 5/16	1 5/16	15/16	1 1/2	7/8	19
1 5/8	2 9/16	18	2 31/32	1 5/16	1 3/8	1 3/8	1 3/8	1	1 5/8	15/16	20 1/2
1 3/4	2 3/4	19 1/2	3 3/16	1 3/8	1 7/16	1 7/16	1 7/16	1 1/16	1 11/16	1	22
1 7/8	2 15/16	20 1/2	3 13/32	1 7/16	1 1/2	1 1/2	1 1/2	1 1/8	1 3/4	1 1/16	23 1/2
2	3 1/8	22	3 5/8	1 1/2	1 9/16	1 9/16	1 9/16	1 3/16	1 13/16	1 1/8	25

1/4-inch engineer's wrench is called for to use on a finished nut, it means a wrench for that size of nut, or on referring in Table 1 to an 1/4-inch bolt, it will be noted that the opening in the head for that size is 1/2 inch between the jaws. If an 1/4-inch cap-bolt wrench is called for, the opening will be 7/16 inch, as shown in Table 3. This point is brought out for the reason that many times a helper is sent for a certain size of wrench, and is found measuring all the wrenches for one with the opening the size called for, instead of one to accommodate the nut size.

For the purpose of becoming familiar with the sizes of nuts for a given tap size, and for use in finding the sizes of drills to be used in drilling for a given size of tap, also to show the strain a bolt of given size will stand, Table 6 is compiled. The sizes for unfinished nuts are not given, but it is well to know that an unfinished nut is 1/16 inch thicker and wider from side to side than a finished nut. A finished nut is 1/16 inch thinner than the bolt sizes.

Proper and Improper Uses of Wrenches

Monkey wrenches of all makes have the general appearance shown in Fig. 28, and it must be said that there is no wrench in existence more misused than this type. They are designed for use by hand on the nuts that they will take, and will stand all work put on them *with the hands only*, giving good service if they are always applied in the proper manner. Invariably on calling for a monkey wrench, one is brought out looking very much like Fig. 41, with the jaws at an angle with each other when closed, instead of being parallel, as they should be. This condition is caused by abuse in the use of the wrench, principally through ignorance.

When the monkey wrench is applied as shown in Fig. 42, there will be no difficulty about it doing its work. When the nut is to be turned in the direction shown by the arrow, the wrench must always be

applied as shown. Not only must the wrench be applied in the right direction, but it must come down full on the nut as far as it will go, the reason being that the force which tends to break the wrench or bend the jaws into the shape of Fig. 41 is along the line *A*, Fig. 42, and with the wrench clear down the leverage is reduced to a minimum.

In Fig. 43 it will be seen that the line *A* is increased by not letting the wrench down on the nut, although the jaws are closed up tight on the nut. Fig. 44 shows line *A* not greatly increased, but through the loose adjustment of the jaws the corners of the nut get a greater purchase on the wrench and tend to push the jaws apart more forcibly. In Fig. 45 the two forces which tend to ruin the wrench have the best opportunity on account of the poor adjustment of the width between the jaws and the wrench resting high up on the nut.

These are common faults in the use of monkey wrenches, but the abuse most common is illustrated in Fig. 46, which shows the wrench upside down. As soon as the force is applied in the direction of the arrow, the outside jaw takes hold of the nut at *B* and line *A* is increased at once. This is positively a case where there is only one way that is right, and any other is wrong. Not only can wrenches be saved by applying them as in Fig. 42, but many skinned knuckles and mashed fingers might have been prevented, and of more importance, considerable time saved. When a monkey wrench cannot be applied to its work properly, some other type of wrench should be used.

Another infallible rule for the right use of a monkey wrench, is to never use a piece of pipe over the handle to increase the leverage. Nor is it right to strike on one of these wrenches with a hammer. Most of the ruined handles on monkey wrenches come from these two sources.

All types of wrenches should be used with care and precision, and should always be placed squarely on the nut and made to fit it snugly. With socket wrenches it is often impossible to use them unless they are held squarely and snugly to the work. Pipefitters often handle Stillson wrenches in a manner destined to ruin the pipe. In screwing up or slacking off on a pipe, always catch the wrench as close up to the thread as possible. Many cases of split pipe have been attributed to the wrench being held at the middle of its length, allowing the pipe to twist under the heavy strain and split the seam.

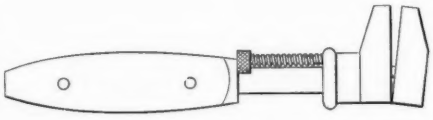


FIG. 41 JAWS AT AN ANGLE

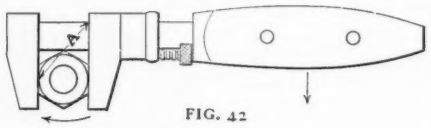


FIG. 42

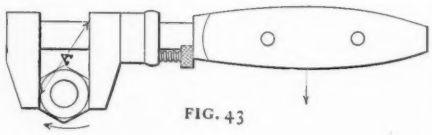


FIG. 43

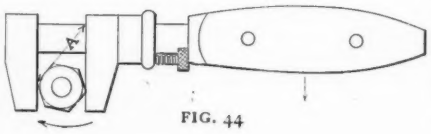


FIG. 44

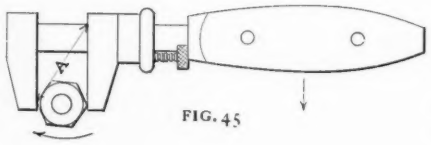


FIG. 45

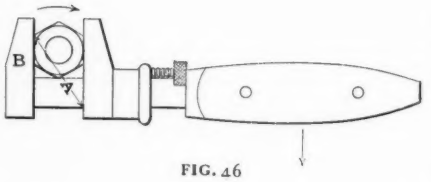


FIG. 46

METHODS OF APPLYING MONKEY WRENCH

Another source of trouble with Stillson wrenches originates from constantly taking hold of the pipe in the same place. When many hard pulls are necessary to set up, the result is a pipe cut through in places. The proper thing to do in taking holds is to move the wrench along the length a little and back again, so that the teeth of the wrench will not grip twice in the same place. A Stillson wrench should also be set down on its work, so that the jaws will take hold with the work well up in them. There is one thing which limits this, however, and that is the amount of pull which the hold must stand. The stronger the pull, the farther up on the work the jaws must be in order for the teeth to take hold. For this reason also, when making a hard pull, it is not advisable to use a very large wrench on small pipe, as the larger teeth may cut through the pipe or crush it.

A Stillson wrench is not so liable to crush pipe as a pipe tongs, and for this reason the former is the best to use. It is best to use a chain wrench on the larger sizes of pipe, discarding the Stillson for sizes over 3 inches. Never use a Stillson on a bolt head, nut, stud or finished work, as there is always a way in which these may be handled with standard or special wrenches.

Kinks

Oftentimes it is necessary to loosen up nuts on bolts which have rusted on. If time is allowed to do so, it will help much to pour kerosene oil over the nut and

TABLE 6. BOLT DIMENSIONS AND THE SIZE OF DRILLS TO CORRESPOND.

Size of Bolt or Tap, Inches.	Number Threads to Inch.	Size Drill for Tap, Inches.	Diameter at Bottom of Thread of Bolt, Inches.	Area in Sq. In. at Bottom of Thread of Bolt.	Stress on Bolt Upon Basis of						Diameter of Opposite Sides of Nut, Finished, Inches.	Diameter of Opposite Corners of Nut, Inches.
					3,000 Lb. Per Sq.In.	4,000 Lb. Per Sq.In.	5,000 Lb. Per Sq.In.	7,000 Lb. Per Sq.In.	10,000 Lb. Per Sq.In.	Possible Breaking Load.		
¼	18.20	11/64	.....	.....	.....	.....	.....	.....	.....	.....	7/16	37/64
5/16	16.18	3/16	.....	.....	.....	.....	.....	.....	.....	.....	17/32	11/16
⅜	14.16	17/64	.....	.....	.....	.....	.....	.....	.....	.....	9/16	51/64
7/16	14	11/32	.....	.....	.....	.....	.....	.....	.....	.....	23/32	59/64
½	13	27/64	0.38	0.12	350	460	580	810	1,160	5,800	13/16	1 9/10
9/16	12	29/64	0.44	0.15	450	600	750	1,050	1,500	7,500	15/16	1 1/64
⅝	11	17/32	0.49	0.19	560	750	930	1,310	1,870	9,000	1	1 5/32
¾	10	21/32	0.60	0.28	850	1,130	1,410	1,980	2,830	14,000	1 1/16	1 7/16
⅞	9	49/64	0.71	0.39	1,180	1,570	1,970	2,760	3,940	19,000	1 1/4	1 11/16
1	8	7/8	0.81	0.52	1,550	2,070	2,600	3,630	5,180	25,000	1 5/16	1 7/8
1 1/8	7	63/64	0.91	0.65	1,950	2,600	3,250	4,560	6,510	30,000	1 7/16	2 3/32
1 ¼	7	1 5/64	1.04	0.84	2,520	3,360	4,200	5,900	8,410	39,000	1 5/8	2 5/16
1 3/8	6	1 11/64	1.12	1.00	3,000	4,000	5,000	7,000	10,000	46,000	1 13/16	2 17/32
1 ½	6	1 19/64	1.25	1.23	3,680	4,910	6,140	8,600	12,280	56,000	2 1/16	2 3/4
1 5/8	5½	1 27/64	1.35	1.44	4,300	5,740	7,180	10,000	14,360	65,000	2 3/16	2 31/32
1 ¾	5	1 ½	1.45	1.65	4,950	6,600	8,250	11,560	16,510	74,000	2 1/4	3 1/16
1 7/8	5	1 ⅝	1.57	1.95	5,840	7,800	9,800	13,640	19,500	85,000	2 ⅜	3 3/32
2	4½	1 23/32	1.66	2.18	6,540	8,720	10,900	15,260	21,800	95,000	2 1/2	3 1/8
2 ¼	4½	.....	1.92	2.88	8,650	11,530	14,400	20,180	28,800	125,000	2 7/16	4 1/16
2 ½	4	.....	2.12	3.55	10,640	14,200	17,730	24,830	35,500	150,000	3 1/16	4 ¼
2 ¾	4	.....	2.37	4.43	13,290	17,720	22,150	31,000	44,300	186,000	4 1/16	4 29/32
3	3½	.....	2.57	5.20	15,580	20,770	26,000	36,360	52,000	213,000	4 1/16	5 ⅜
3 ¼	3¼	.....	3.04	7.25	21,760	29,000	36,260	50,760	72,500	290,000	5 5/16	6 7/64
4	3	.....	3.50	9.62	28,860	38,500	48,100	67,350	96,200	385,000	6 1/16	7 3/32

allow it to loosen up the rust. If the kerosene will not loosen up the rust enough, then take a hammer and strike the nut sharply on all sides. To do this properly, hold another hammer squarely against the nut on the opposite side. This will loosen up badly rusted nuts, but if it does not do the work, then more kerosene will be needed.

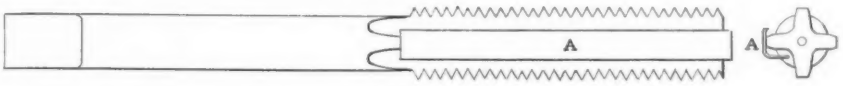


FIG. 47. TIN COVERED TAP TO ENLARGE NUT

When Necessary, Split the Nut

Sometimes a loosened nut will start off and again stick before entirely off. This is caused by the thread of the nut or bolt stripping, and if continued, will ruin one or the other. More often it is the bolt or stud which suffers, and the only way to save them is to split the nut apart. To do this, take a flat chisel and cut into one side, opening the nut up from top to bottom through the center of one flat. Hold a heavy hammer or piece of iron against the nut on the side opposite while doing the cutting.

On pipe flanges it is often cheaper to split all the nuts that are rusted in than to work to get them off with a wrench, providing plenty of spare nuts are available. If this is done, the bolts should be given a bath in kerosene before being used again.

When Nut and Bolt Do not Fit

In some cases nuts will not go on bolts or studs because the nut is tapped a little small or the thread on the bolt is too large. More often it is the latter, and the thread on the bolt should be made smaller to fit the nut, so as to keep the nuts of uniform size. When time, circumstances or material will not allow of the thread being turned down on the bolt, and a tap of the right size is to be had, the nut may be tapped larger as follows:

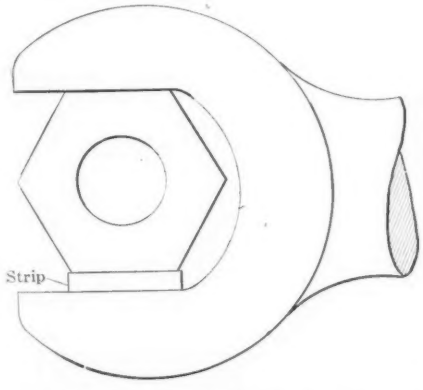


FIG. 48. WRENCH TOO LARGE FOR NUT

Cut into a strip of tin of the right width and length and bend it into the shape shown at *A*, Fig. 47, and just wide enough to cover one set of threads on the tap and long enough to reach over the ends of the threads, as shown. Enter the tap into the nut with this tin over the threads, and the threads in the nut will be enlarged. Some difficulty may be experienced in starting the tap through the nut, but after starting it, it will follow through all right. Use the first tap of a set for this, or as it is called, the taper tap.

Fitting Wrench to Bolt Head

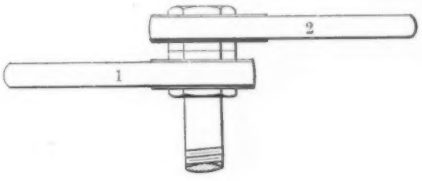
When a wrench does not fit a nut or bolt head (the wrench being too large) and no other is to be had, it is permissible to use a strip of iron, steel or any other metal substance handy to fill up the space between the jaws, as illustrated in Fig. 48. For convenience of handling, the strip can be longer than shown.

Turning a Stud

A great many do not know how to readily remove a stud from its place, when necessary, with the tools at hand. Fig. 49 illustrates how two nuts may be locked together on a stud to withdraw it. If the length of the thread will permit, run two full nuts down on the stud, with the two flat sides of the nuts coming together. Take the two wrenches, as shown in the plan, and pull them together. Note the angle at which the top and bottom wrenches are held in this figure, for if the respective wrenches were held at the same angle and changed, No. 2 to the bottom and No. 1 to the top, the pull together in the direction of the arrows would have the effect of loosening the nuts. The rule of operation is, that while facing the nuts, take wrench No. 2 in the right hand and place it on the top nut and wrench No. 1 in the left hand and place it on the bottom nut at the angles shown or anywhere under the line *A B* down to *C D*. To lock the nuts, pull the wrenches together, and to loosen them, change the top wrench to the bottom, and *vice versa*, and pull them together. There are several other ways of using the wrenches to attain these ends, and in some instances other ways must be found, but this manner of doing it allows the operator to get the strongest pull either while tightening up or slacking off.

To get the greatest purchase on the nuts, place the wrenches at an acute angle from each other, say along the lines *F* and *G*, respectively, while still standing in the same position. After the nuts are locked, if it is intended to take the stud out, take one wrench and use it on the bottom nut to back out a right-hand thread, and if the stud is to be driven in, use the one wrench on the top nut.

Where a great many studs are to be driven home to stay, a stud driver, such as is shown in Fig. 50, can be used. It can be made from a special nut drilled and tapped half-way through its length, and is run down on the thread until the stud bottoms in the nut. When the stud is driven as far as it will go, remove the stud driver by giving it a quick, strong twist with the wrench, in the opposite direction to that followed while driving the stud.



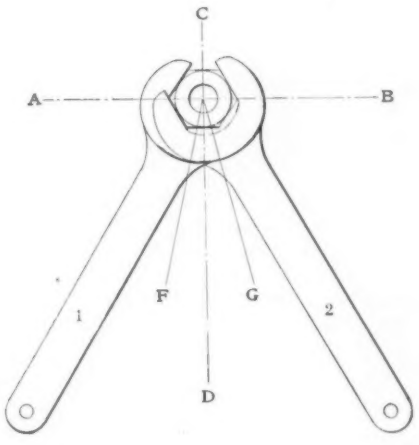


FIG. 49. LOCKNUT METHOD OF TURNING STUD

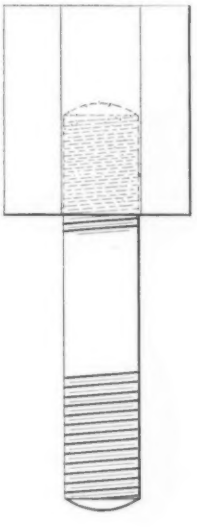


FIG. 50. STUD DRIVER

Increasing the Leverage of a Wrench

It is often desirable to increase the leverage of an ordinary engineers' wrench, and the practice is permissible

under certain conditions. Never use a hammer on the handle, as it ruins it. If a sharp blow is required, use some form of a soft hammer, or use a block of hard wood for a ram. It is still better to make a handle of pipe sufficiently long to give the desired leverage. Flatten one end of

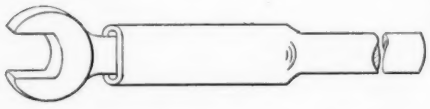


FIG. 51. INCREASING THE LEVERAGE

the pipe to fit over the wrench handle, running the flat back far enough to allow the handle to be run in up to the head, as shown in Fig. 51. It must be remembered that there is a limit to the size of bolt or stud on which it is advisable to use a longer leverage on the handle of the wrench than the makers have allowed for. Bolts up to and including 7/8 inch in diameter can be twisted off with an ordinary wrench and a muscular operator, so that pipe handles are not to be tolerated on any size smaller than that.

Pulling up Joints

All joints should be pulled up square and even all around from start to finish, especially where a metal joint is used. Dirt being left on joint surfaces often causes leaks, because the two cannot be brought evenly together, and just as often the leak is caused by the uneven strain on the bolts. Take, for example, the cylinder head shown in Fig. 52, which has a shoulder all around the inside of the flange. It will be seen that by pulling on one nut first, the head could be tipped out of true, and only one edge of the shoul-

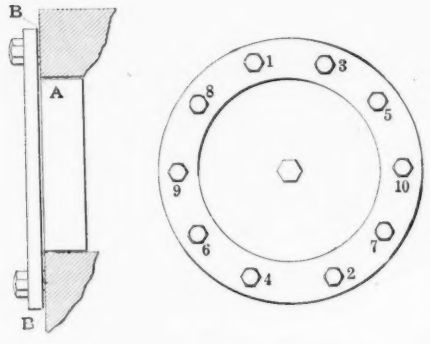


FIG. 52. TIGHTENING UP A CYLINDER HEAD

der joint would touch. When first starting to set up on the nuts, a good method to follow is to set up on No. 1 nut lightly until the surfaces of the joint meet, then take up the same on No. 2 nut opposite to No. 1, then Nos. 3 and 4 in succession, after which the nuts can be taken up the same amount in the order given. Then go over them all again in the same order until the joint is tight. The space *B* will be equal all around if the pulling up has been properly done. This rule applies equally well on all joints, taking any nut for No. 1 and making No. 2 come opposite. Some bolt circles are divided as in Fig. 53, where one nut will be on the center line *A B* and opposite to it the nuts will straddle, perhaps not just as shown in the illustration, but similar. In this event, take up on the nuts in rotation, as indicated by the figures.

Screwdrivers

A screwdriver with a wedge-shaped head which fits the slot of the screw, as at *A*, Fig. 54, is a type which never should be used, and yet is universally sold by manufacturers and used in that form. It is plain that this form of screwdriver never fits the slot in the screw head and takes as much force to hold the driver in place as it does to drive the screw. Another fault is that it puts a strain on the screw head where the power which tends to break it apart is greatest. When the head of the screwdriver is ground so that it takes hold of the screw head in the bottom of the slot, as at *B*, Fig. 54, the strain on the screw head is at a minimum, and the power of the operator is all spent in driving the screw alone. All screwdriver heads should be made as shown at *B*, Fig. 54.

In some cases it is impossible to use ordinary screwdrivers, owing to the cramped space, and the driving force must be applied at right angles to the driving line. Fig. 55, *A* and *B*, show views of two screwdrivers which are useful in such cases. It can be seen that with *A* the screw head can be moved one-fourth of a turn and be picked up with *B* and turned another quarter, when *A* can be used again and so alternately until the work is done.

Things in General

On very large nuts or bolt heads it is necessary to use more than a straight pull. A sharp blow with a hammer often starts an obstinate hold, where a straight pull would not. It is not advisable only in extreme cases to use the hammer on the wrench, but a hardwood block will do as well. In extreme cases a steady pull aided with blows of a ram will do the work. Very extreme cases call for the use of a block and fall on the end of a large wrench and a ram in addition. An aid to the wrench on large sizes of nut, when it is desired to have the nuts extra tight, is to heat the bolts before they are put in place. To do this properly, heat the bolts midway of their length to a dull red, and then place them in position and set up on the nut quickly. The contraction of the bolt will make the nut hold more tightly than a wrench can set it, if the job is done quickly and in a proper manner.

The use of a hammer and chisel on nuts and bolts in place of a wrench is not to be condoned in general practice, for it puts the nuts forever beyond the possibility of using a wrench on them. There are times and places where a wrench cannot be had, and a hammer and chisel must be used. When this is necessary, use a calking chisel or drift so as to spare the nut as much as possible. Then have a suitable wrench made. The illustrations will offer suggestions to fit any case.

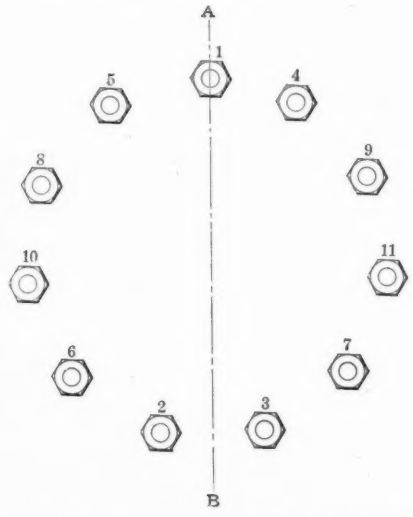


FIG. 53. TIGHTEN NUTS IN ROTATION

Several years ago in one of our Western Indian agencies there was employed an old man called Uncle Bill by the rest of the Government employees. He was a good mechanic of the old school and was often called on to loan his monkey wrench to others. He would do so once, and the borrower could have it again if he showed that he could follow Bill's instructions as to its proper use. If not, and they failed to apply the wrench rightly to its work, they need never ask again for the loan of it. He was right, for he had no wrenches

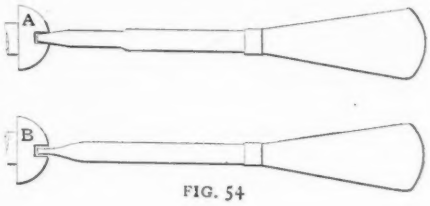


FIG. 54

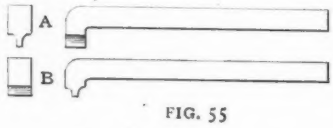


FIG. 55

FORMS OF SCREWDRIVER

to spare, and this article may serve to enlighten the reader as to the reasons why.

Niagara river develops 8,500,000 continuous horsepower. If two pounds of coal were burned per horsepower per hour, the hourly amount necessary to equal the work of Niagara river would be 8500 tons. Continuous work for a year would require over 74,000,000 tons of coal.

An Early American Engineer—Robert Erskine

Sketch of the Life and Activities of One of the Men Who, in Colonial Times, Did Much to Advance Engineering in Many Departments

BY EDWARD P. BUFFET

Among the men of note in our colonial days were few who could be called "engineers" in any sense of the word. Robert Erskine deserves that appellation in many senses. He made his mark as a civil, an hydraulic, a mining and a military engineer, a mathematician, a metallurgist and a first-class works manager. There is a strong hint that he was also something of a steam engineer.

The same old Scottish city—Dunfermline—which furnished our most successful industrial leader of the nineteenth century supplied one who is entitled to almost an equal rank for the eighteenth. As a Scottish ironmaster on American soil, Robert Erskine might be called the Carnegie of the colonies. He differed from Carnegie in being more of an engineer and less of a financier.

His active career was divided between the old and new countries. In the former he established his reputation as inventor of pumps, machine designer and consulting engineer, while in the latter he closed his career as an industrial executive, intrusted with interests of great responsibility.

In the library of the New Jersey Historical Society have been on file for nearly half a century the venerable documentary records of his work—portfolios of family and other letters relating to his early life; numerous manuscripts describing his inventions and their exploitation, with sketches and wash drawings; a dissertation on the tides; account books of the American works; and a volume in which his own epistles concerning their administration are laboriously copied out. There are also many pages written in cryptic characters which may be either shorthand or cipher. The mass of material, if edited with discriminating selection, would form an interesting volume. It is curious that among his sketches, although a century and a half have told upon the tint of the ink lines, the pencil marks remain perennially fresh. Very few of these documents have yet been published, though a few extracts were given by Rev. Dr. Tuttle, a famous local historian by whom the papers were secured for the society.

Robert Erskine was born September 7, 1735, his father being the Rev. Ralph Erskine, minister at Dunfermline, a man of sufficient note to find a place in encyclopedias down to the present day. Ralph's title to fame was acquired by founding, with his brother, Ebenezer, a free branch of the Scottish kirk and in being the author of several books, including a volume of "Gospel Sonnets." A copy of the latter was long ago exhumed by the writer of this memoir in a nook of an old house on Long Island. It was a ninth edition, Glasgow imprint of 1760, and contained, apart from the body of the book, a poem of uncertain authorship, entitled, "Smoking Spiritualized." The verses inculcate a number of edifying lessons that may be drawn from the pipe, its contents and its use.

Robert Erskine's father died in 1752, when the lad was 17. The youth evidently received a collegiate education, or its equivalent, for we find him in London in the sixties, well grounded in scientific knowledge and casting about after opportunities to make it useful. The following letter from his mother indicates that he had his eye on a place in the faculty of Glasgow University:

Dear Robbie—I received your's this day. I wrot to you this day eight days with a shipmasters recept for a box to you with some linnings which youl have got by this time. I shall be very glad that I am in a mistake about your being oblidged to be present as a candidat for ye vacancy at Glesgow it was the openean of your Brother and many others that you should be present but if it is needless it may be they may cause you yet for to be sure the professerss is not pleased with that Buchannan but is like as ye *D* of Argyl is hear he will oblidge them to take him fit or unfit if he serves his turn I think you have got a suffisceant swack of his Gress as I hope you will expect no favours from him it would be a great mercy if you could think of doing something hear for I am afrayd you will get some offers to go to Jemeky Gebrealter or some of the colonys abroad which would be very disagreeable to me. . . .

GRAVES OF ERSKINE (ON THE RIGHT) AND MONTEATH

It appears that a professorship of mathematics, or some such branch, was suggested to him as a genteel occupation, but although he possessed the theoretical tastes of a university scientist, he had also the instincts of a practical engineer. His ultimate triumphs must have been reached through struggle and vicissitude, and there is graphic evidence of the financial embarrassment to which he was at one time subjected.

Among the inventions that Erskine de-

veloped as practical machines, was a "centrifugal engine," or rather pump, very simple in principle. If, as he shows, we have a pipe not too long for suction and shaped as an inverted L, the lower end being immersed in water, and if after having started a stream flowing, we continue to revolve the pipe with sufficient speed about its vertical axis, the centrifugal force of the water in the arm will produce a continuous flow. The top part may, if desired, be made in hollow disk form, with

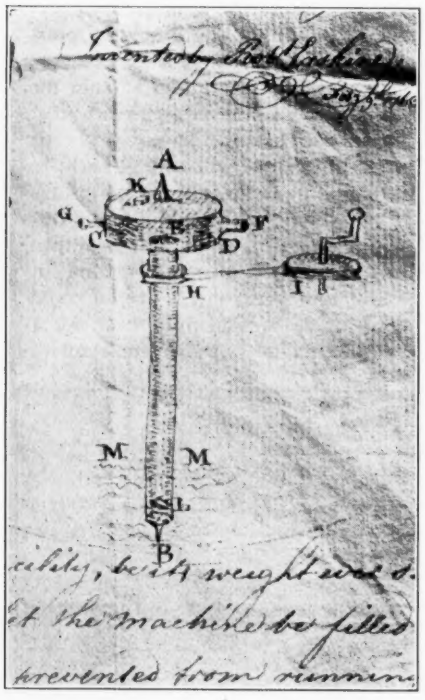


FIG. 1. PRINCIPLE OF THE "CENTRIFUGAL ENGINE" PUMP

several orifices, but their total cross-section should be less than that of the inlet pipe. The mechanical development of this conception was easy. Obviously the device possessed advantages as a pump through minimizing the number of moving parts and reducing frictional losses. The Erskine papers contain several sketches of this pump whether in its most elementary form or put into more marketable shape. Fig. 1 is a drawing that appears on a sheet bearing date February 9, 1763, the time of the writing or of the invention.

This centrifugal pump was offered as a competitor of the chain pump for bailing out ships, which led to a pumping of the ink bottle by their respective protagonists. Disputes over the features of a machine were waged in print 140 years ago quite after the modern fashion, but since specialized engineering papers like POWER did not then exist, the general press served as a forum for the discussion.

A correspondent of the *Gazetteer*, signing himself "W. B.," had atacked the centrifugal pump in favor of the chain pump, for we find among the Erskine manuscripts drafts of a letter to the printer of that newspaper in rejoinder, taking to task "W. B." for having "endeavored to impose on the *ignorant*." One such document is signed with Erskine's name, and another somewhat differently worded, with the disinterested *nom de plume* "Mechanicus." It does not appear which he employed in the letter as finally sent off.

He opened his defense with a remark that the invention had been suggested by a problem which one of the *Gazetteer's* own correspondents had proposed, viz., "contrive a method to make the siphon run out of the shorter end by means of an air pump." Erskine stated that one of the machines might be seen at Mr. Coles', near St. Thomas' Coffeehouse, on the Strand, and proceeded to describe it. With such a pump six men could raise 2 tons of water a minute at least 20 feet. The delivery increased faster than in proportion to the power applied. The radius of the ejecting tubes of the present engine, designed for a 60-gun ship, was 4 feet. He went on to compare the velocities of motion of the centrifugal and chain pumps under practical conditions of operation and to demonstrate that "W. B." had assumed for the operation of the chain pump feats of sustained human activity quite unreasonable to expect. Further, he pointed out that his own machine possessed advantages in its simplicity, high mechanical efficiency and freedom from liability to injury by anything less than a cannon ball.

Fumbling further among the old documents we come across a copy of a certificate by a committee to a comparative test of these two types of pump on board H. M. S., "Princess Mary," at Woolwich, 1766. The chain pump was in exceedingly good order. Ten stout men were allowed to each. Erskine's raised, in ten minutes, 14¾ tons of water, and the chain pump 11½ tons.

The Mr. Coles, to whom reference has been made was the builder of Erskine's pumps. The documents contain proof of extensive dealings between them, some of which were not altogether harmonious. One of the papers is an award of arbitration in a dispute with the result that Mr. Coles was not to make any of certain machines for 12 years. Another of Erskine's memoranda is a permit to certain men to build a machine for their own use in consideration of making one for him within a definite time.

Another of Mr. Erskine's inventions was a "continuous stream pump," which was an ordinary double-acting one in principle, though having an external contour that suggests the pulsometer. (Does Erskine pose as originator of the duplex pump?) Fig. 2 is a sketch of it, while Fig. 3, is an illustrated circular or data sheet relating to a form of it as constructed for domestic uses.

The drawing, Fig. 2, appears in a letter by Erskine to Mr. Watthews, or Matthews, watchmaker, on Fleet street, February 11, 1766, which concludes by describing methods of raising water where there is a fall. He writes:

> If the situation of the place is such that the hight from the surface water to the back level is *greater* than from the back level to the bottom from whence the water is raised, if this is the case there is a method of raising the water from the bottom to the back level [bv] the force of the surface water (if the back level is but a few feet lower than the middle of the pit) without any machinery at all and the same quantity of water that runs down from the surface can be made to flow up from the bottom, it will only require the attendance of a boy to turn the cocks and I suppose will last some centuries. It is called Hero's fountain. I have seen it described with four cocks and some valves, but could improve it to want only two cocks and by a little study and some few experiments I believe I could make it work without any attendance at all . . . . P. S. I.

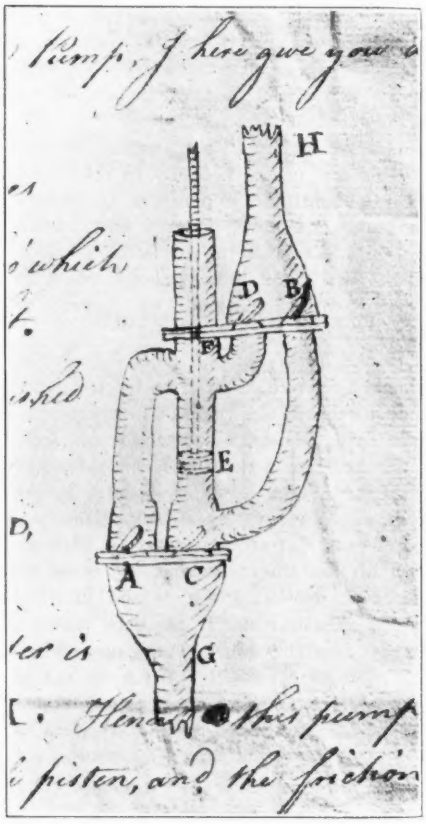


FIG. 2. "CONTINUOUS-STREAM" PUMP

never undertake to design and give a drawing of any machine for less than five guineas.

The foregoing device was manifestly intended to perform some such task as is now done by the hydraulic ram. Some of Erskine's papers are filled with his study over a device which he terms a "quadruple Hero's fountain," by means of which he sought, "with a fall of 6 feet to raise 1/6 of the whole stream." The stream was

divided among five troughs, each of which communicated with five vessels, all except one or both at the ends being air-tight. Below them were five other cells piped from near their bottoms to the bottoms of the ones directly above and also piped from their tops to the upper parts of the ones above next adjacent on the left. (The reader may from this description draw his own diagram.) By this means the pressures could be accumulated from right to left so that in the upper vessel farthest to the left the water would rise 24 feet, 20 feet of which was lift. The Prussia. Lists of installations show us that his machines had considerable vogue.

Robert Erskine's hydraulic proficiency must have been a valuable asset for him when, as we shall shortly learn, he came to America, for the development of water powers in northern New Jersey and southern New York was carried on extensively during colonial days. The damming of streams and collection of water in large reservoirs was then resorted to for power purposes on a scale second only to modern undertakings in the same region to supply cities with water. Furthermore, it was his selection for a position of great responsibility in the colonies. He was engaged, about 1771, to go to America and retrieve the failing fortunes of an iron trust. His salary was to be £370 a year, with sundry additional allowances.

The New York and New Jersey Iron Works, American Company, or London Company, as variously called, was a British concern possessing industrial interests to the value of nearly a quarter of a million dollars at Ringwood, Long pond (now Greenwood lake), and Charlotteburg, N. J., and Cortlandt Furnace, N. Y. The plant that figures most prominently was that of Ringwood, within the limits of the present Passaic county, N. J., close to the New York line. The nucleus of the industrial estate had been established by the Ogdens, a famous New Jersey ironmaster family, who had purchased the land in 1740 and sold out in 1764 to the London company, organized by an alert German, Baron Peter Hasencleven, one of the most distinguished colonial ironmakers. He floated a loan or stock issue, to which both gentlemen and ladies of high station in England subscribed, and brought over 535 persons from Germany as a laboring population. There were some 75 square miles or more of territory comprised in the undertaking. Energetically he set about enlarging the plants. By the end of a couple of years they were equipped with four forges, seven furnaces, a pot- and pearl-ash manufactory (on the Mohawk river), 235 workshops, stores and dwelling houses, dams for 13 mill-ponds and 10 bridges, with many miles of roads. One of his dams was 860 feet long and 12 feet high. But like many other early American manufactories, the works failed to pay, and about 1769 he went into bankruptcy, partly, at least, through the misconduct of a partner. By a chancery suit lasting many years, Hasenclever received more or less vindication of his conduct. Though adventurous, he was a sincere and amiable man, and according to the best information he afterward became a successful linen manufacturer in Silesia. In the management of the American business he was succeeded by John Jacob Fæsch, a Hessian, whom he had brought over, and under whom the works remained unprofitable. Hasenclever's bankruptcy does not seem to have destroyed the company, since the interests that employed Erskine were, at the time, in controversy with Hasenclever. Erskine toned his correspondence with much bitterness against both Hasenclever and Faesch, and he did his utmost toward prosecuting Faesch at law. Though doubtless honest in this course, he is open to suspicion of undue animosity. Faesch remained in the vicinity to conduct iron works of his own, and he died with a character highly esteemed.

After Erskine had held the management for a few months, he was asked to report on the advisability of selling the

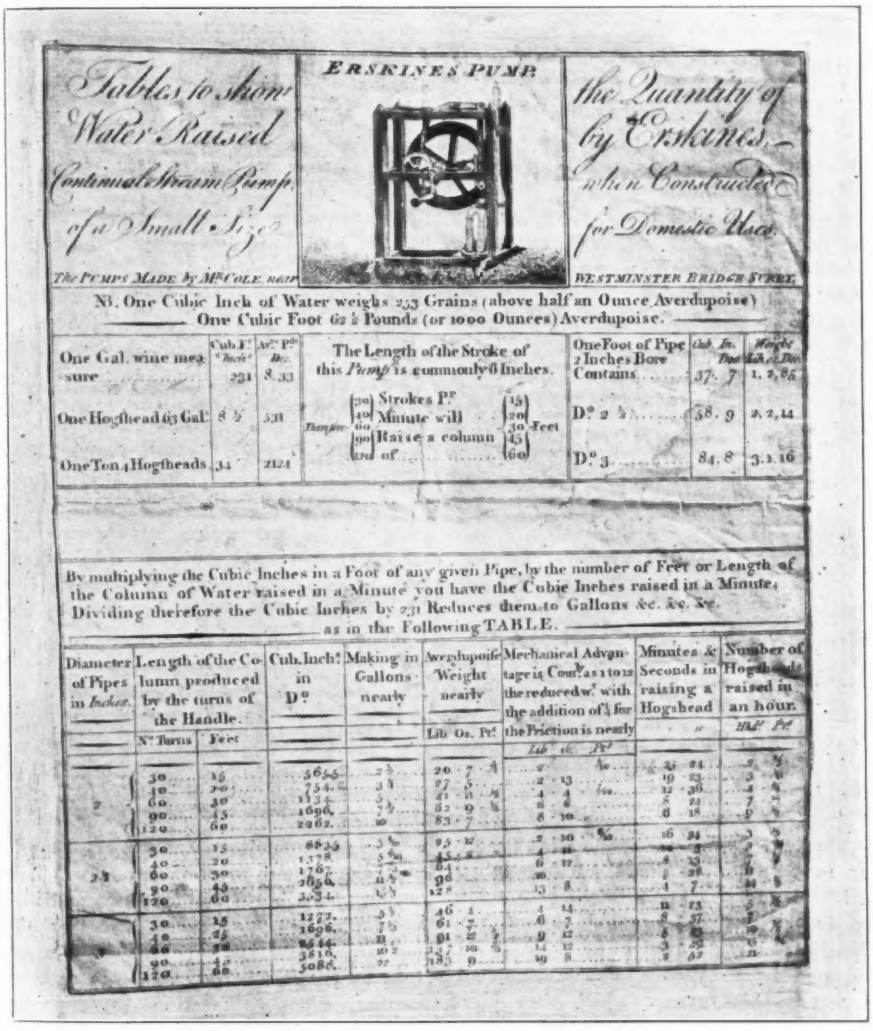

Tables to shew
Water Raised
Continual Stream Pump
of a Small Size
ERSKINES PUMP
the Quantity of
by Erskines
when Constructed
for Domestic Use
The Pumps Made by Mr Cole, near
Westminster Bridge Surrey
N.B. One Cubic Inch of Water weighs 253 Grains (above half an Ounce Averdupoise)
One Cubic Foot 62 ½ Pounds (or 1000 Ounces) Averdupoise.
One Gal. wine measure 231 8.33
One Hogshead 63 Gal. 8 ½ 531
One Ton 4 Hogsheads 34 2124
The Length of the Stroke of this Pump is commonly 6 Inches.
Strokes P.r Minute will Raise a column of Feet
One Foot of Pipe 2 Inches Bore Contains 37. 7 1. 2, 85
D.o 2 ½ 58. 9 2. 2, 14
D.o 3 84. 8 3. 1. 16
By multiplying the Cubic Inches in a Foot of any given Pipe, by the number of Feet or Length of the Column of Water raised in a Minute you have the Cubic Inches raised in a Minute; Dividing therefore the Cubic Inches by 231 Reduces them to Gallons &c. &c. &c.
as in the Following TABLE.
Diameter of Pipes in Inches
Length of the Column produced by the turns of the Handle.
N.r Turns
Feet
Cub. Inch.s in D.o
Making in Gallons nearly
Averdupoise Weight nearly
Lib Oz. Pt.
Mechanical Advantage is Cou.as 1 to 12 the reduced w.t with the addition of ⅓ for the Friction is nearly
Minutes & Seconds in raising a Hogshead
Number of Hogsheads raised in an hour.

FIG. 3. DATA SHEET OF "CONTINUOUS-STREAM" PUMP

biographer assumes no responsibility for a complete explanation of the details of the machine, nor for its performance according to contract.

Altogether, Mr. Erskine's pumps displayed considerable variety in type and purpose, and in motive power, which might be hand, horse or hydraulic. Characteristic of his engineering activity was the design of plants to meet particular conditions of raising water on gentlemen's estates. Draining mines was another utility. Among orders received by 1765 was one for a large centrifugal engine (pump) to be used in salt works of the king of a prime requisite of a mine operator that he should know how to handle pumps.

But Erskine's ingenuity was not confined to hydraulics. He invented a horizontal windmill and a musket rest. The wash drawings extant contain designs of nautical or mathematical instruments also. His versatility is suggested by a letter to the *London Chronicle* on treating smallpox. His eminence is shown by the fact that he was made a fellow of the Royal Society. Whatever may have been, or failed to be, the financial profits of his technical skill, he won a high reputation for integrity and ability, as is proved by

works at a sacrifice. His advice, though given with caution, was adverse to such a project. "I am but a taming the Forgemen," he wrote, "though there are several ways in which your expenses may be lessened and your profits increased." He alluded moreover to his intention of trying the sulphury ore in the furnace and to his belief that another body of ore might be found near Charlotteburg. Manifestly, his counsel to hold the works prevailed.

After taking charge, Mr. Erskine adopted the plan of writing long letters to the company or interested individuals at home describing the state in which he found things and the methods of his management. Some letters he regarded as of so confidential a nature that he felt it nec essary to write and copy them with his own hand, which he esteemed quite a burden. Today a correspondence equal in magnitude and importance would be dictated to a stenographer or a phonograph between puffs of a cigar.

These reports make an interesting picture of so multifarious an industry as a large ironworks of colonial times. It was a little self-sufficient world, utilizing the products of the soil in many different ways, with a systematic division of labor. In his control of ore and fuel supplies, transportation facilities, etc., Erskine was a primitive Carnegie. He was not, however, like Carnegie, at liberty to work up his pig and bar iron into finished products. If his company had announced the erection of a steel furnace or of a rolling mill beside Long pond, such as, upon a memorable occasion, Carnegie proposed to build at Conneaut, by Lake Erie, the concern would not have been bought out by its competitors with 5 per cent. first mortgage bonds, but would have fallen into the clutches of the law. For the policy of the British government was to reserve the manufacture of finished iron materials as a home monopoly against the colonists, by a principle much like that which the United States follows in some of its dealings with the Philippine islands. A parliamentary act of 1750 had forbidden the erection in America of any new steel furnace or rolling or slitting mill, etc. After that, none could be put up unless to operate by the moonshine method, like the slitting mill of Samuel Ogden, at Old Boonton, which, it is said, ran under the innocent guise of a grist mill.

"The concerns of the company for which I am engaged," wrote Erskine to one of his correspondents, "are very great. The amount of their inventories at New Year in iron, goods, cattle and movables alone was upward of £30,000 currency; the annual circulation of cash and supplies is between £20,000 and £30,000. . . . . I have eight clerks, about as many overseers, forgemen, founders, colliers, wood cutters, carters and laborers to the amount of five or six hundred."

"I design to follow," he remarked, in beginning a report to the proprietors, "the natural order of things as they arise. Wood, Charcoal and Ore are the First in Course the furnace, its Construction and appurtenances, the Roasting, mixing and smelting of ore into pig metal come next, together with a variety of other articles which may occur during (the time when the furnaces) are in Blast, then come the forges with all their connections, which will include the processes of the Manufactory of Bar Iron faults improvements. etc. Provisions and necessaries, Farms, Horses, Cattle, Carriages, Roads, Mills, Dams, Houses, etc., must follow."

Among other subjects requiring discussion were his system of bookkeeping and his relations with labor. He outlines the various time- and piece-work methods by which are paid the different sorts of workman—carters, blacksmiths, coalstockers, furnace fillers, founders, miners, forgemen, managers, clerks, overseers. The lower grade he has found hopelessly in debt to the company store, and describes how he has won the gratitude of some carters by raising their wages £5 a year to a total of £60. The company, he suggests, would better have contented employees than a deceptive balance in its favor, and from other quarters than pinching the hard-earned wages of the laborer he is sure the proprietors would wish their profits to arise. Yet he favorably contrasts the lot of even the poorest with that of their equals in Scotland and Ireland. The necessities of the cheaper workmen keep them bound to the company stores, but the more highly paid, such as the forgemen, do better by purchasing provisions from neighboring farmers. The company itself obtains supplies from these farmers and Erskine denounces their extortion in demanding New York prices for their produce.

"Faesch gave me all the trouble he could," wrote Erskine somewhat later. "The founder at Charlotteburg almost overset [?] the furnace (to appearance on purpose) for which I put him in jail till he found security to answer an action of £200 damages I brought against him. He [Faesch?] decoyed away some of our Forgemen too, to work in some forges adjacent to his furnace which they hired and most of the poor Creatures have been kept without work at the top of all the money they earned at your work, and are now come and earning again very thankful to be employed and will make the better hands than ever."

"The last time I was in Charlotteburg," remarked Erskine in one of his letters, "a bar of iron was tried on purpose to see how many strokes it would take to break it, when it bore above fifty blows of a sledge hammer upon an anvil before it gave way." Again, he is gratified to note that his iron has acquired among the country blacksmiths a reputation for being "plaguy tough." Iron from Charlotteburg, after trial, was marked cold with a star of five rays, from Ringwood with one of six and from Long pond with one of seven.

Fame has fastened upon the steam engine erected at the Schuyler copper mine, near the Passaic river, New Jersey, by Josiah Hornblower, 1753-55, as the first one installed in America. It would appear that Erskine imported engines only a few years later, since in a letter which he must have penned early in 1772 he states: "I hope the Fire Engines are finished and on the way which I mentioned last autumn." "Fire engines," as we should be aware, meant, in that day, steam engines. It is not to be inferred that Erskine ceased to depend chiefly on water power to drive his blowers and other machinery. Doubtless his engines were intended for pumping mines at a distance from any stream.

The term "fire engine," however, was also applied in the modern sense, to pumps for extinguishing fire. In that day they were, of course, driven by hand power. As long ago as 1719, the city of Philadelphia paid "for ye ffire engine." It is entirely possible that the machines imported by Erskine were intended to check the spread of conflagrations in the numerous buildings of his works. Whether they were of this sort or were truly steam engines, may be left as one of the great unanswered riddles of history.

It is significant to peruse Mr. Erskine's letters to his employers as noises of the awakening insurrection of the colonies began to be heard and until correspondence was broken off by the progress of the revolt. Candidly he interpreted to them the sounds of disturbance and gave them due warnings of what was coming. In June, 1774, he said: "I have no doubt that a total suspension of commerce to and from Great Britain will certainly take place. Such I know are the sentiments of those who even wished a chastisement to Boston."

He writes under date, August 2, 1775, that the British man-of-war "Asia," is turning back boats with produce and iron from the Jerseys, in consequence of the restraining act. He will forward as much iron as possible before the tenth of September, when exportation ceases. On October 31 he advises of the probability that the seat of war will be transferred to New York and the business of the works be interrupted. February 10, 1776, he writes, inclosing his cash account for January.

As it proved, the works were kept in operation during the war, since they were within the lines of the insurgents, for whom they became a prolific source of munitions, including some of the iron work of the Hudson river obstructions. Preponderant sentiment in New Jersey and New York hardly sustained the wisdom of the rebellion, yet Erskine eventually threw in his fortunes with it. He organized the employees of the works into a company of militia which he equipped at

his own expense. The rebels, moreover, made him geographer and surveyor general to their "Continental army." There is said to be in existence somewhere a letter received by Erskine from Mr. Washington, the leader of the insurgent bands, asking him if he considered himself the proper sort of man for the above-mentioned job. In entering upon this office he again reminds us of Mr. Carnegie, who undertook public service as Eastern superintendent of military railways and telegraphs in the war between the States.

That Erskine was an honest man is evidenced by the books of accounts which he continued to keep with the proprietors of the iron works, whom we may assume still to be the English ones, and to whom, although cut off by the war, he acknowledged a persisting business obligation. The salary with which he credited himself jumped from £370 in 1777 to £1125 in 1778 and £1110 in 1779, which would look like an attempt to make hay while the sun shone did not the inflation of the currency suffice to explain the apparent raise.

WORK OF HYDRAULIC POWER, NEAR RINGWOOD

Robert Erskine did not live to see the rebellion successful. He died October 2, 1780, the day that Major Andrè was hanged, and was buried at Ringwood. Mr. Washington came from the gallows at Tappan to attend his funeral. It may be presumed that after the end of the war, if not before, the iron works were sold by the State of New Jersey under confiscation proceedings. These were one of the methods of persecution by which the victorious party took revenge against the loyalist fellow countrymen. Non-resident Britishers, such as the London Company, would not be likely to fare better. The estate may have been split up at this time. It was manifestly divided in ownership a few years later when it was visited by a French author known as the Marquis of Crèvecoeur. He found the Ringwood and Charlotteburg plants in the hands of separate managers to whom he refers as proprietors. The master of Ringwood was a Mr. Erskine, who was doubtless a son or nephew of the great engineer. A few extracts from Crèvecoeur's narrative are pertinent to quote:

"The proprietor of these [Ringwood] works, Mr. Erskine, had, as we knew, spent three years in Europe visiting the principal forges of Scotland, Sweden and Germany. His operations, although less extensive, seemed to us no less interesting. The construction of the different machines intended to simplify the work was even more perfect than what we had seen at Sterling. A large *movement* for flattening and slitting the iron into rods appeared to Mr. Herman a *chef d'oeuvre* of simplicity, but what rendered it yet more curious was the flour mill by which it was surmounted, and which could be lowered when it was wanted for use and raised when the grinding was finished. . . . [Regarding the forests in this part of the country, one of visitors remarked to Mr. Erskine]:

"'If your posterity preserves these beautiful woods it will for many centuries enjoy the precious advantages of having the charcoal necessary for making iron, facilities for repairing buildings and dams, and all the power required.'

"'You are right,' said Mr. Erskine. 'It is probable that this will come to pass, since the entire chain has long been the property of a few individuals extremely interested in the preservation of the forests.' . . . .

"Next day we came across a very mountainous country to Charlottenburg. The works here had been erected before the Revolution by an English company, which the war had ruined. The . . . proprietor was absent. . . . The water reservoir was immense." . . .

The preservation of natural resources was a consideration even in the eighteenth century. It is true now, as it was then, that the Ramapo mountain country is largely held in single ownerships amounting to many thousands of acres each. The hills are remarkably wild for a region only forty or fifty miles from New York city hall, though I do not venture to say how much of the wood is primeval forest or merchantable timber. At villages not far from Paterson the wildcats are so tame that they come and eat out of the ash barrel. Charcoal burning has ceased to be a necessary industry, but the water powers of the region ought to be valuable. It is probable, however, that the available water will all be needed for municipal supply. A few years ago there was a project to pipe it to New York, but so many political ptomaines were mixed in that the water would have poisoned anyone who had drunk it. One of the accompanying illustrations shows a washout by the bursting of a pond or reservoir at Sterlington, not far from Ringwood, in a freshet five years ago. I am told that practically all of the gulley visible was cut by the flood and that the water reached the eves of houses on the plain below.

A little journey to Robert Erskine's grave at Ringwood was made in the course of preparing this sketch of his career. The place has long been occupied by the Cooper-Hewitt interests, who still conduct mining operations there, and the country for miles around is kept up as a magnificent residential estate. It was the home of the late Mayor A. S. Hewitt, of New York. C. S. Stites is the courteous superintendent of the industries. A considerable stream filled with ripples that suggest hundreds of unused horsepower flows down from the north and forms a lake near which the Erskine grave is situated. As shown in the photograph, the slab at the right is Erskine's while at the left is buried his clerk, Robert Monteath, also of Scotland, who preceded him in death by several years. Near the former tomb is an old stump which does not look very beautiful, and the author-photographer intentionally kept it out of the field of the picture. Information has since been received that the tree was planted there by Mr. Washington (no doubt as a penance for cutting down the cherry tree), but the reader may be consoled for failure to see it by a reiterated assurance that it is quite an ordinary stump and not a bit more worth looking at than those which are planted by the hand of nature.

A vainglorious cow insisted upon posing for her picture.

Testing and Adjusting Watt-Hour Meters

Practical Methods of Handling Westinghouse Instruments, with Wiring Diagrams Showing Proper Connections for Best Results

BY O. F. DUBRUIEL

Every well-equipped power station, in order to get satisfactory performance by its watt-hour meters, should have its own meter department, provided with the best appliances possible for overhauling, testing and checking the meters. The premises containing this department should be absolutely free from vibration and equipped with solid, substantial testing racks. These racks should be suitably provided with lampboards, switchboards and resistances so arranged that the loads through the meters can be easily changed and each load can be maintained at a constant value while readings are being taken.

In testing, a constant voltage is essential and this voltage should be that which is applied to the meter terminals when the meter is installed. To obtain the various voltages for the testing racks a potential regulator is a most convenient piece of apparatus. A transformer with a number of loops brought out from the secondary winding to binding posts will, however, accomplish the same results, but the former is always to be preferred.

It is essential for accurate work that the best standard instruments should be obtained, for good results cannot be secured with inferior instruments. These standard instruments may consist of voltmeters, standard integrating watt-hour meters, standard indicating wattmeters and stopwatches.

There are two methods of checking a watt-hour meter calibration. The first method is by comparing the meter to be checked with a standard indicating wattmeter. When using this method the instruments should be connected to the circuit and a constant load applied; by timing the disk a composition load can be obtained. The second method is by comparing with a standard integrating watt-hour meter; by this method it is only necessary to notice which of the two instruments was in synchronism to determine whether the wattmeter in question is in correct calibration. A well-equipped station should have the necessary instruments to check by either method.

To Test a Westinghouse Type A Two-wire Single-phase Meter

Connect the wattmeter in circuit with a standard indicating wattmeter as indicated in Fig. 1, being careful to make the connections exactly as shown. Load the circuit until the desired reading is obtained on the indicating wattmeter and keep it at a constant value while the integrating watt-hour meter is being read. Time the number of revolutions of the disk with a stopwatch, commencing to count when the spot on the disk has made one revolution (after the watch has been started), and count the revolutions for at least one minute to arrive at the number of watt-hours registered by the meter. Use the following formula:

$$\frac{K \times R}{S} = watts,$$

where R = number of revolutions made by the disk, S = time to make revolutions and K = constant, which is equal to the volts multiplied by the amperes (as marked on the counter) and multiplied by 1.2. When this type of instrument is used with series transformers, and checked without them, K = volts as marked on the counter multiplied by 6. For wattmeters used with series and shunt transformers but checked without them $K = 600$.

When testing with the standard integrating watt-hour meter connected as shown in Fig. 2, when more than one meter is to be checked against the standard, it should be connected as shown in Fig. 3, but only one meter can be run with the standard at a time; otherwise the meter nearest the line connection will measure the energy taken by the shunts of those nearest the standard.

Type B Single-phase Meter

The formula for this meter is the same as before, but in this case, with the two-wire meter, K = volts × amperes (as marked on the counter) × 2.4. For meters used with series and shunt transformers, but checked without them, K = the rated watts × 5 × 2.4, since these meters have five-ampere series windings.

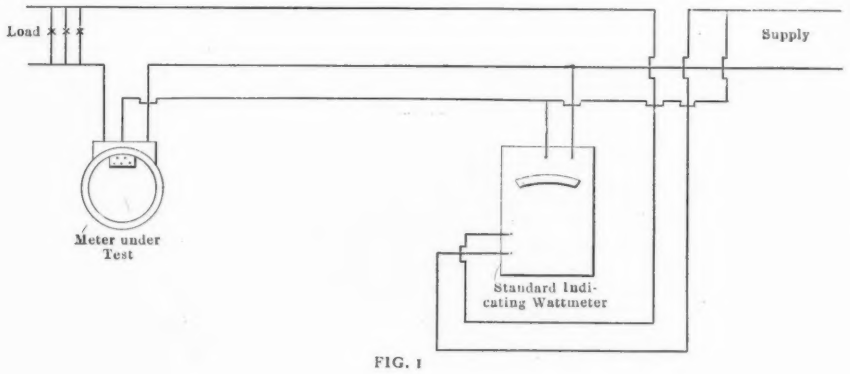


FIG. 1

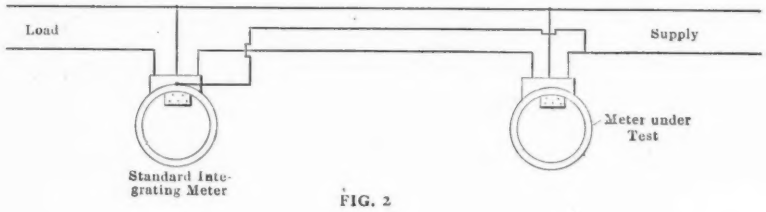


FIG. 2

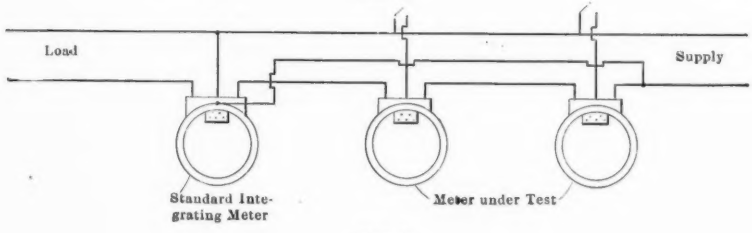


FIG. 3

For Type B three-wire single-phase self-contained meters used with acid transformers, K = constant or volts × amperes (as marked on counter) × 4.8, and for Type B three-wire single-phase meters used with transformers, K = volts (as marked on the counter) × 12.

For Type C three-wire single-phase

meters up to 40 amperes capacity, $K =$ volts (between outside wires as marked on the counter) $\times$ 2.4, and for Type C polyphase meters, without series or shunt transformers, $K =$ volts $\times$ amperes $\times$ 4.8; for meters used with series transformers only (but checked without them) $K = 5 \times$ volts (as marked on the counter) $\times$ 4.8, and $K = 2400$ for meters used with shunt and series transformers, but checked without them.

In checking polyphase meters it is best to check them as single-phase meters; that is, check over one element of the time. See Figs. 4 and 5.

To check a polyphase meter as a single-phase meter connect the current coils in series and the potential coils in parallel.

Type F Long Scale Indicating Wattmeters for Alternating Current

For accuracy in using these indicating wattmeters the following should be taken into account: In all indicating instruments there are two kinds of error, an initial error independent of the load, which is due to traces of friction, parallax, coarseness of the divisions on the dial, etc., and an error proportional to the reading due to inaccuracies in calibration errors in the standards used, and causes varying the constants of the instruments. In the Type F instrument the former error amounts to five-tenths of one per cent. of the full scale reading, and the latter to five-tenths of one per cent. of the actual reading; therefore, to find the total error at any point within which the readings may be relied upon, the following formula should be used:

$$\textit{Per cent. total error} = \frac{0.005\,A + 0.005\,a}{a},$$

in which $A =$ full scale capacity and a the actual reading. Any visible zero error should be allowed for in reading.

In the lamp-testing wattmeters the initial errors amount to one-tenth of 1 per cent. of the full scale reading and the proportional error to two-tenths of 1 per cent. of the actual reading. Therefore, to find the total error at any point within which the readings may be relied upon, the following formula should be used:

$$\textit{Per cent. total error} = \frac{0.001\,V + 0.002\,v}{v},$$

in which $V =$ full scale capacity and v the actual reading; any visible zero error should be allowed for in the reading.

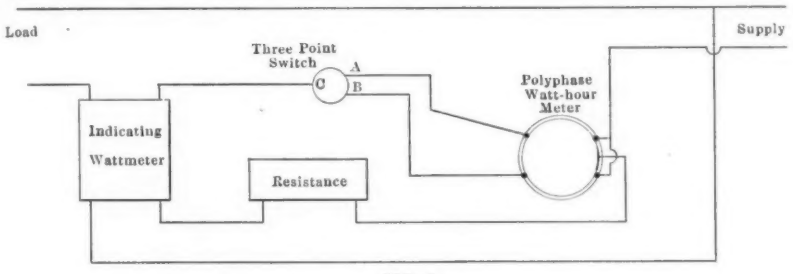


FIG. 4

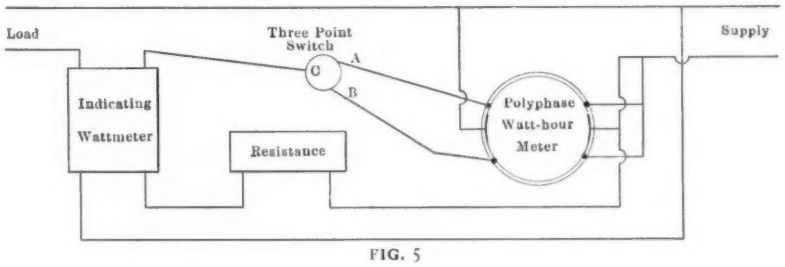


FIG. 5

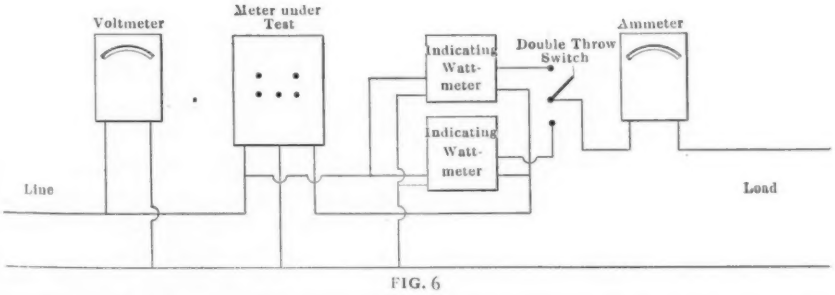


FIG. 6

Portable Long Scale Indicating Wattmeter for Alternating Current

The accuracy of the calibration of this instrument may be stated by saying that the errors of full scale reading amount to two-tenths per cent. and those of the actual reading two-tenths per cent. Therefore, to find the error of calibration at any point the following formula may be used:

$$\textit{Per cent. error} = \frac{0.2\,W + 0.2\,w}{w},$$

in which $W =$ full scale capacity, and w the actual reading. Any visible zero error should be allowed for in the reading. For example take a 100-kilowatt instrument indicating 50 kilowatts:

$$\textit{Per cent. error of calibration} = \frac{0.2 \times 100 + 0.2 \times 50}{50} = 0.6$$

per cent.

Wishing to find the number of seconds S in which the disk should make the test number of revolutions with a certain load, use the following formula:

$$\frac{K \times R}{P} = S,$$

where

$K =$ Constant,
$R =$ Number of revolutions in test,
$P =$ Watts indicated by indicating wattmeters.

The value of K may also be found by transposing the formula, thus:

$$K = \frac{P \times S}{R}.$$

Connect the polyphase meters as shown in Figs. 4 and 5. This connection shows the meter in a single-phase two-wire circuit with a standard indicating wattmeter. Be sure that the connections are made exactly as shown in the sketch. Both shunt circuits of the integrating watt-hour meter are connected with the main circuit; however, the current passes through only one series coil at a time by connecting the point C to either A or B. When this one circuit of the meter is fully loaded the rotating element will make one-half the number of revolutions which it makes with full load on both circuits. Now pass through the circuit a given number of watts which must be kept as constant as possible while the reading is being taken. After the test has been made on one side the same test should be made on the other side. If C is connected to A in the former test, connect it to B, and *vice versa;* the shunt connections remain the same as in the first test. The main current is now, however, passed through the other circuit, the first series circuit being entirely disconnected. Be sure that both shunts are connected when testing.

Fig. 6 shows the connections that will be made on a testing board where direct and alternating watt-hour meters are tested by the use of a voltmeter, two indicating wattmeters, a double-throw switch and an ammeter. When testing direct-current meters use a wattmeter a voltmeter and an ammeter, and for alternating current use a voltmeter and an indicating wattmeter. Two indicating meters are used, one with a small range and the other with a large range, in order to avoid errors in reading a small load at the lower end of the scale of a large instrument.

Calculating Strength of Riveted Joints*

A New and Original Method Dispensing, by the Use of Diagrams, with the Labor Involved in the Usual Calculation

BY S. F. JETER

The purpose of the present article is to show how most of the labor involved in the calculations of riveted joints, as generally applied to boiler construction, may be dispensed with. The method of doing this is by the use of diagrams, and while those shown in connection with this article are all based on tensile strength of the plate, shearing strength of the rivets and crushing strength of the rivets, of 55,000, 42,000 and 78,000, and 95,000 pounds per square inch, respectively, the methods used in constructing the diagrams will be explained fully and the formulas given, so that those who are concerned with the design of such joints, or who may frequently have to calculate their efficiency, can construct diagrams to suit their special requirements as regards the above mentioned values.

After the principles are thoroughly understood, it will be found a very easy task to construct the diagrams, and the writer has found that the labor involved may be greatly reduced by making use of standard cross-section paper, a very convenient size being 16x21 inches divided in tenths. This can be procured from any dealer in drawing materials for five cents per sheet. It is, of course, not essential to have the form of joint shown in the corner of the sheet, but it was done in the present case merely as an aid in explaining the diagrams; a written description of the joint would answer equally as well. It is impossible to explain the diagrams or the method of their construction without the use of formulas or the aid of analytic geometry; it is, however, not necessary that the reader be versed in either the use of formulas or analytic geometry to make full use of the diagrams in shortening the calculations necessary to determine the efficiency of the various joints considered.

The method, about to be described, of determining the probable mode of joint failure directly without calculation and comparison of values is entirely original with the writer, and as far as he can ascertain it is different from any method which has been previously published on the subject. The principle may be stated thus:

With a given diameter or area of rivet and fixed values for the tensile strength of the plate and crushing and shearing strength of the rivets, straight lines or curves may be drawn, representing values of pitch of rivets or thickness of plate, or both, at which either of the two compared possible modes of failure would be equally probable. Representing the pitch of the rivets by distances on the axis Y and the thickness of the plate by distances on the axis X, or *vice versa*, lines may be drawn representing comparisons between all of the possible modes of joint failure for a given rivet diameter, and the most likely mode of failure, for a given pitch of rivets and thickness of plate, can be determined without calculation by noting the direction in which the point of intersection of the lines, representing the pitch of the rivets and the thickness of plate lie, with respect to the lines denoting equally probable failure.

In the following explanation for all forms of joint the notations given hereafter will be adhered to.

T = Tensile strength of plate per square inch, in pounds.

S = Shearing strength of rivets per square inch, in pounds, when subjected to double shear.

s = Shearing strength of rivets in pounds per square inch, when subjected to single shear.

C = Crushing strength of rivets in pounds per square inch of projected area of contact between rivets and plate.

P = Pitch of rivets, in inches.

d = Driven diameter of rivet, or diameter of hole, in inches.

t = Thickness of plate, in inches.

In joints that have more than one pitch, P always represents the greatest pitch of rivets. The dimensions corresponding to P, d and t are given on the drawings illustrating the forms of joints in the upper corner of each diagram.

Bearing in mind the notations just given and considering a single-riveted lap joint, the three modes of possible failure, as given in the previous article on page 28 of the July 7 number of POWER AND THE ENGINEER, would be represented as follows:

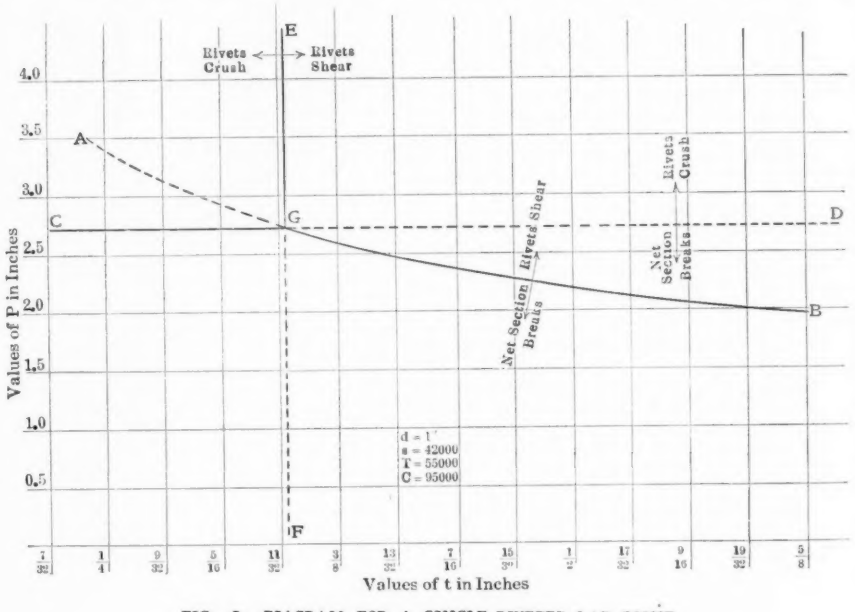


FIG. I. DIAGRAM FOR A SINGLE-RIVETED LAP JOINT

Breaking of net section between rivet holes

$$t\ T\ (P - d) \qquad (1)$$

Shearing of rivets

$$0.7854\ d^2\ s \qquad (2)$$

Crushing of rivets

$$C\ d\ t \qquad (3)$$

By making (1) and (2) equal to each other and solving for P, the following would result:

$$t\ T\ (P - d) = 0.7854\ d^2\ s,$$

or

$$P = \frac{0.7854\ d^2\ s}{t\ T} + d.$$

*Copyrighted, 1908, by S. F. Jeter.

Substituting in this equation the values of 55,000 for T and 42,000 for s, it would become:

$$P = \frac{0.6\,d^2}{t} + d. \qquad (4)$$

Now if values for t and P are laid off on the axes of X and Y, respectively, and this equation is plotted with any fixed value for d, a curve would be obtained, and if the pitch and thickness indicated by any point on this curve was used in constructing a single-riveted lap joint, the probability of failure by breaking the net section or shearing the rivets would be the same, and since an increase in pitch would strengthen the net section, without adding strength to the rivets to resist shearing, all points lying above this curve would denote corresponding values for pitch of rivets and thickness of plate that would cause joint failure by shearing of the rivets rather than breaking of the net section of the plate, and conversely, points lying below this curve would indicate breaking of the net section of the plate, rather than shearing of the rivets. Again, if equation (1) is made equal to equation (3), the following results are obtained:

$$t\,T\,(P - d) = C\,d\,t$$

or

$$P = \frac{C\,d}{T} + d,$$

which reduces to

$$P = 2.73\,d \qquad (5)$$

when $T = 55{,}000$ and $C = 95{,}000$.

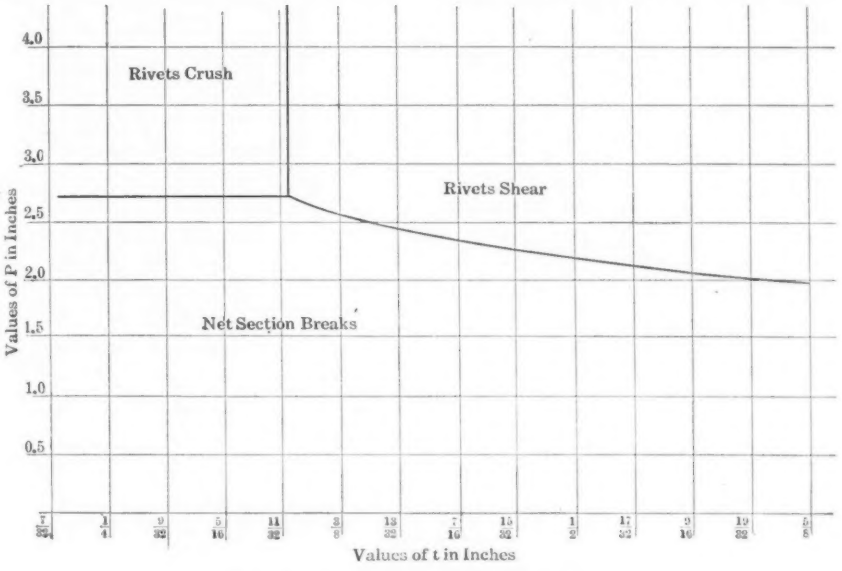


FIG. 2. DIAGRAM OF FIG. 1 SIMPLIFIED

This equation represents a line parallel to the axis of X and at a distance $2.73\,d$ above it; a joint designed with this pitch of rivets would be equally as strong to resist rupture by crushing of the rivets or breaking of the net section of the plate with any fixed value for d, and since an increase in pitch of rivets would add strength to the net section of the plate, without adding to the strength of the rivets to resist crushing, all points lying above this line would represent pitches which would cause the crushing of the rivets to be more likely than breaking of the net section of the plate, and conversely those values of P lying below it would indicate joints where the net section of the plate would be weaker than the rivets.

Making equations (2) and (3) equal each other, which is the last comparison possible, the following results are obtained:

$$t = \frac{0.7854\,d\,s}{C},$$

or

$$t = 0.347\,d \qquad (6)$$

when $C = 95{,}000$ and $s = 42{,}000$. This equation represents a line parallel to the axis of Y and at a distance $0.347\,d$ from this axis, and since an increase in the thickness of the plate increases the capacity of the rivets to resist crushing, but does not add to their resistance to shearing, all values to the right of this line would indicate joints which would fail by shearing of the rivets rather than by crushing them, and conversely, those to the left would indicate crushing of the rivets rather than shearing them.

In Fig. 1 equations (4), (5) and (6) have been plotted, assuming a value of 1 inch for d. Line $A\,B$ represents equation (4), line $C\,D$ equation (5) and line $E\,F$ equation (6). The lower line represents the axis X, while the axis of Y and the origin are $\frac{7}{32}$ inch or seven units of thickness to the left of the last vertical line on the left. As may be noted, the three lines representing the equations intersect in a common point G, and if a joint should be constructed of one-inch rivets and with the pitch of rivets and thickness of plate equal to that indicated by this point, failure would be equally probable by shearing of the rivets, crushing of the rivets or breaking of the net section of the plate and this would also be a joint of maximum efficiency.

The arrows pointing from each side of the three lines denote the mode of probable failure for values of P and t each side of the line in the directions indicated. Since all values lying to the left of $E\,F$ would give joints in which the rivets would crush instead of shearing, the portion of the line $A\,B$ denoting comparison between the breaking of the net section and shearing of rivets, which lies in this area $A\,G$, can be dispensed with, for in estimating the strength of joints, it is necessary to compare only the strength of the section most likely to fail with the strength of the solid plate. Since all of the area to the left of $E\,F$ denotes joints which would crush the rivets rather than shear them, the only comparisons which would be of value in this area would be that between the crushing of the rivets and the breaking of the net section of the plate, which is represented by the line $C\,G$. For similar reasons, the line denoting comparison of the strength of the net section of the plate, with the crushing strength of the rivets, lying to the right of $E\,F$, or $G\,D$, can be removed; the lower portion of line $E\,F$, or $G\,F$, has no significance, as the area below $C\,G\,B$ indi-

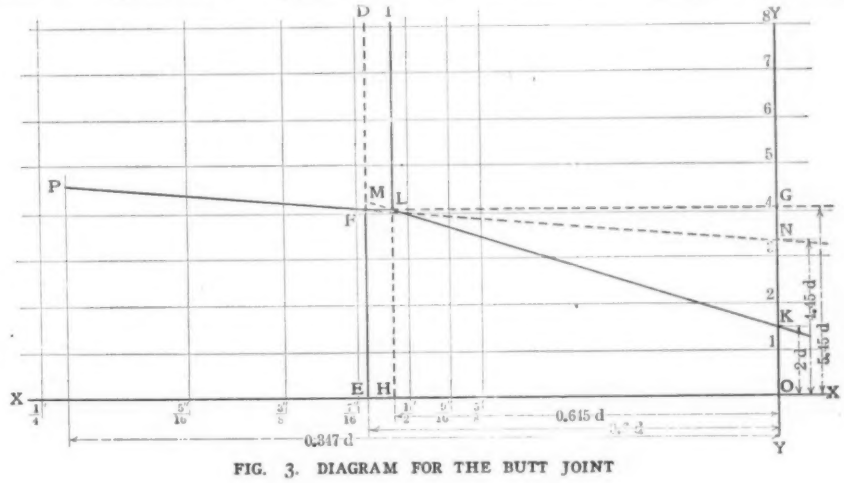


FIG. 3. DIAGRAM FOR THE BUTT JOINT

cates pitches and thicknesses of plate where the net section of the plate is weaker than either the shearing or crushing of the rivets, and therefore there is no need of determining the relative probability of failure by these two methods in this area. Removing the dotted portions of the various lines, a diagram like Fig. 2 will result, and all corresponding values of P and t which lie in each of the three divisions, would indicate joints which would fail in the manner noted in Fig. 2.

The previous description of the principles involved in making a diagram for a single-riveted lap joint holds good for all forms of joints with one pitch of rivets, as all equations of such joints, giving comparative values between the different modes of possible failure, are of the same form as (4), (5) and (6).

It will be noted that the equation of equality between the breaking of the net section of the plate and the shearing of the rivets, equation 4, is that of a hyperbola, and since it is very tedious to plot such a curve, the value of this method of shortening the labor involved in the calculation of joints would be greatly lessened if there were no way of obviating this difficulty, but a very simple expedient may be made use of, so that all equations may be represented by straight lines. This may be accomplished by laying off the values of t along the axis of X, equal to the reciprocals of the thicknesses instead of directly equal to them, and then equation (4) becomes

$$P = \left(\frac{1}{t}\right) 0.6\, d^2 + d,$$

or a straight line cutting the axis Y at a distance d above the axis X. Since the intersection of the lines representing equations (5) and (6) give another point of this line, it is only necessary to join the two points by a straight line to obtain all intermediate values.

In the accompanying diagrams the origin is to the right of the sheets, and the reciprocals of thickness were multiplied by six, so that the line representing ¼-inch plate is 24 inches to the left of the origin. This scale of thickness for the range covered by the diagrams will be found very convenient. Two different scales are used for the pitch, one twice as great as the other, and the bottom line does not represent the axis of abscissas in all diagrams, because the diagrams could be made more compact and to a more readable scale in the space available by making such variations. The drawing in the upper corner of each sheet represents the type of joint for which the diagram is constructed, and the small diagram immediately below the joint is a guide to aid in the use of the main diagram, which may be illustrated as follows:

Assume that we have a double-riveted lap joint with a plate thickness of ⅜ inch and 13/16 inch diameter rivet holes, pitched 3 inches apart, and that we wish to know what efficiency this joint will have. Starting at the bottom of the sheet for this type of joint (page 00) at the line denoting a plate thickness of ⅜ inch, follow up this line until the line denoting a pitch of 3 inches intersects it, and holding a pencil on this point, look for the line denoting a rivet diameter of 13/16 inch. It will be noted that this point lies in the upper right-hand section of the diagram formed by the lines denoting 13/16-inch rivets, and it is shown by the guide diagram that points in this area indicate that the rivets would shear, so that to find the efficiency of the joint it is necessary only to estimate the shearing strength of the rivets and divide the result by the strength of the solid plate. If the rivet holes had been ⅞ inch in diameter instead of 13/16 inch, the point of intersection of pitch and thickness of plate would lie in the area denoting that the net section was weak, and the efficiency of the joint could be obtained by dividing the length of the net section by the pitch.

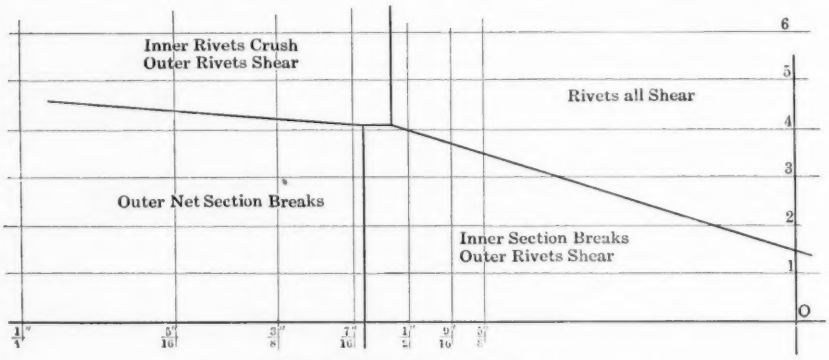


FIG. 4. OMITTING THE DOTTED PORTIONS IN FIG. 3

The following are the equations for the various lines used in the diagrams for joints of one pitch; the letters indicating the lines refer to those shown on the guide diagrams in the corners of the sheets.

SINGLE-RIVETED LAP JOINT

Line O K:

$$P = \frac{C\,d}{T} + d.$$

Line O L:

$$t = \frac{0.7851\,d\,s}{C}$$

Line O M:

$$P = \frac{0.7854\,d^2\,s}{t\,T} + d.$$

DOUBLE-RIVETED LAP JOINT

Line O K:

$$P = \frac{2\,C\,d}{T} + d.$$

Line O L:

$$t = \frac{0.7854\,d\,s}{C}.$$

Line O M:

$$P = \frac{1.5708\,d^2\,s}{t\,T} + d.$$

TRIPLE-RIVETED LAP JOINT

Line O K:

$$P = \frac{3\,C\,d}{T} + d.$$

Line O L:

$$t = \frac{0.7854\,d\,s}{C}.$$

Line O M:

$$P = \frac{2.356\,d^2\,s}{t\,T} + d.$$

SINGLE-RIVETED BUTT JOINT

Line O K:

$$P = \frac{C\,d}{T} + d.$$

Line O L:

$$t = \frac{0.7854\,d\,S}{C}.$$

Line O M:

$$P = \frac{0.7854\,d^2\,S}{t\,T} + d$$

DOUBLE-RIVETED BUTT JOINT, ONE PITCH

Line O K:

$$P = \frac{2\,C\,d}{T} + d;$$

Line O L:

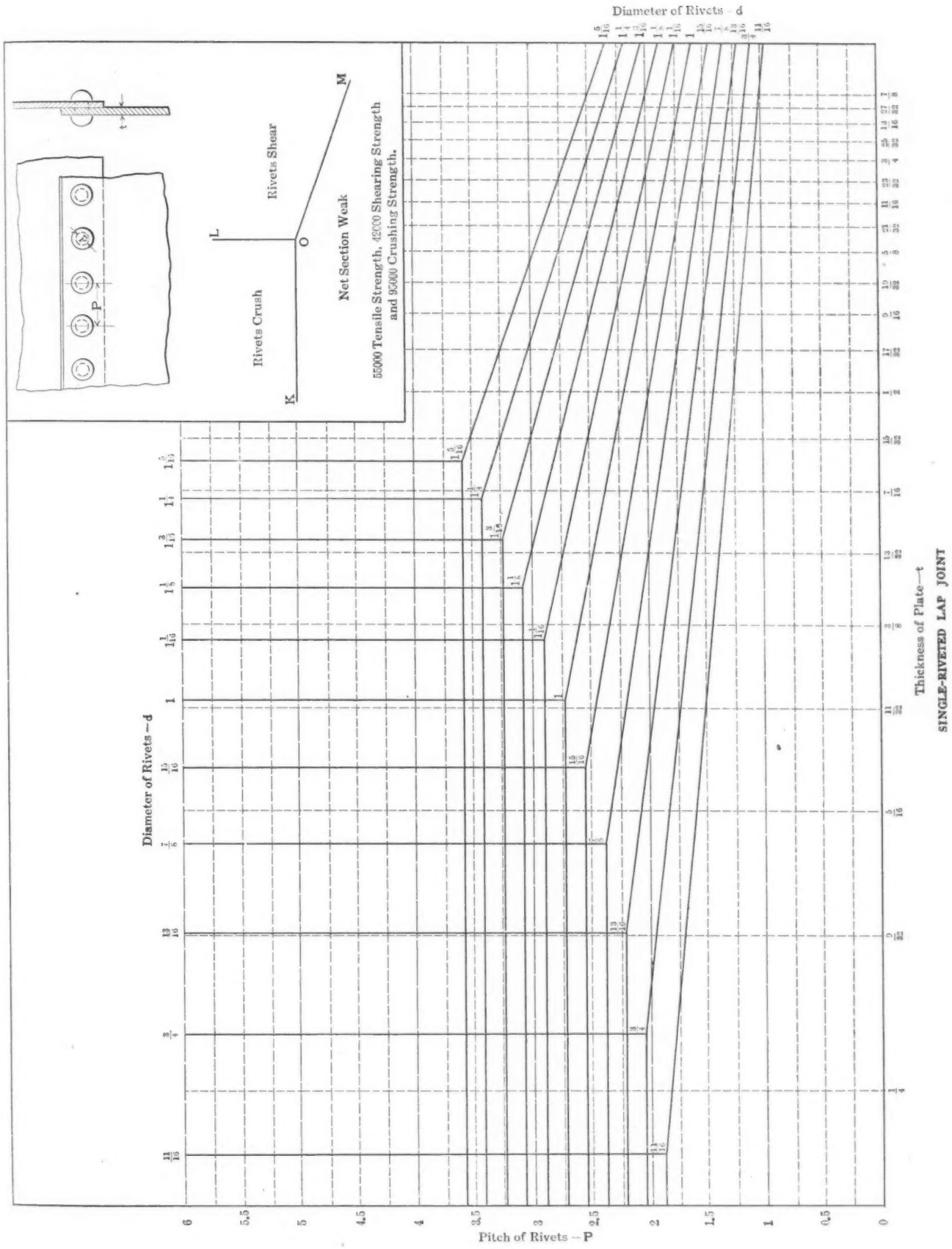
$$t = \frac{0.7854\,d\,S}{C}$$

Line O M:

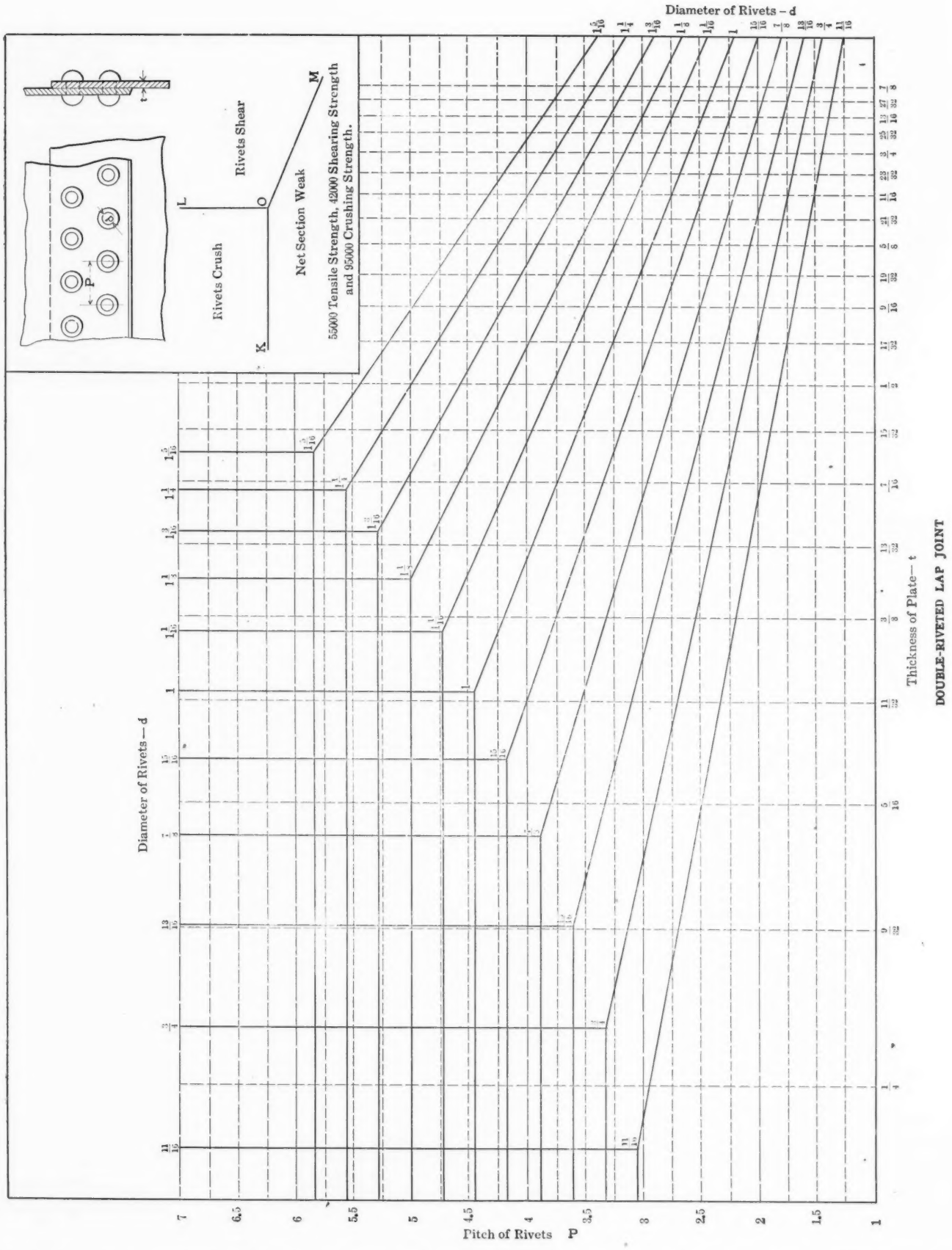
$$P = \frac{1.5708\,d^2\,S}{t\,T} + d.$$

BUTT TYPE OF JOINTS WITH MORE THAN ONE PITCH

For the butt type of joint where more than one pitch of rivets is used, obtaining the equations and plotting the diagrams is a little more complicated. However, their use is just as simple as for the other joints, and the labor saved by the use of the diagrams is many times greater, as can readily be appreciated by anyone who has plodded through the uninteresting task of obtaining desired results in designing this type of joint by the old cut-and-try method. It will be noted on pages 31 and 32 of POWER AND THE ENGINEER, July 7, that six probable modes



of failure are considered in the calculation of double-, triple- and quadruple-riveted butt joints, as illustrated in Figs. 18, 19 and 20 of that article. Two of the possible modes of failure hinge on the crushing of the rivets in the outer rows in the plate or strap. Now it is evident that to have a continuous line to represent the equations from which the diagrams are plotted, it is necessary that t represent the variable thickness of only one member of the joint, and it therefore can represent the thickness of the sheets only. To meet this contingency and have the diagrams care for all the factors which determine the strength of a joint, the lines representing the rivet diameters have been started at such a value of t that the crush-



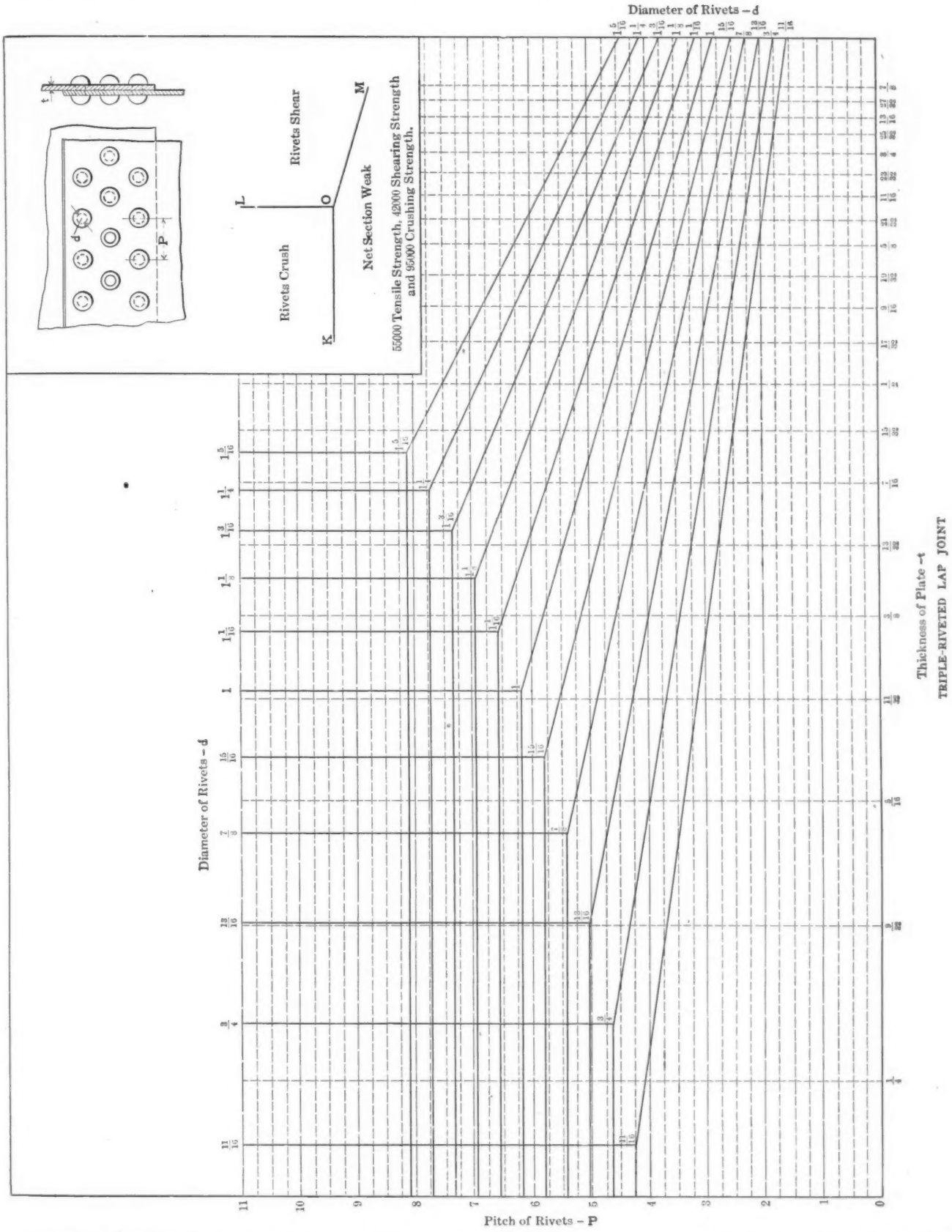
ing of the rivet or shearing in single shear would be equally probable, and as they extend to the right from this point, it is only necessary in using the diagrams to see that the thickness of the straps and plate come within this range, to make the diagrams hold good. It will be found that all practical boiler joints of the double-strapped butt type come well within this range. This expedient also reduces the modes of possible failure to four, which are:

(*A*) Breaking of outer net section.

(*B*) Breaking of the inner section and shearing outer rivets single shear.

(*C*) Crushing of inner rivets and shearing outer rivets single shear.

(*D*) Shearing all rivets, both double and single shear.


Diameter of Rivets – d
Rivets Shear
Rivets Crush
Net Section Weak
55000 Tensile Strength, 42000 Shearing Strength and 95000 Crushing Strength.
Diameter of Rivets – d
Thickness of Plate – t
TRIPLE-RIVETED LAP JOINT
Pitch of Rivets – P

Considering a double-riveted butt joint, with two pitches, and using the notations given in the first part of this article, the value of the four methods of joint failure here given may be expressed by the following equations:

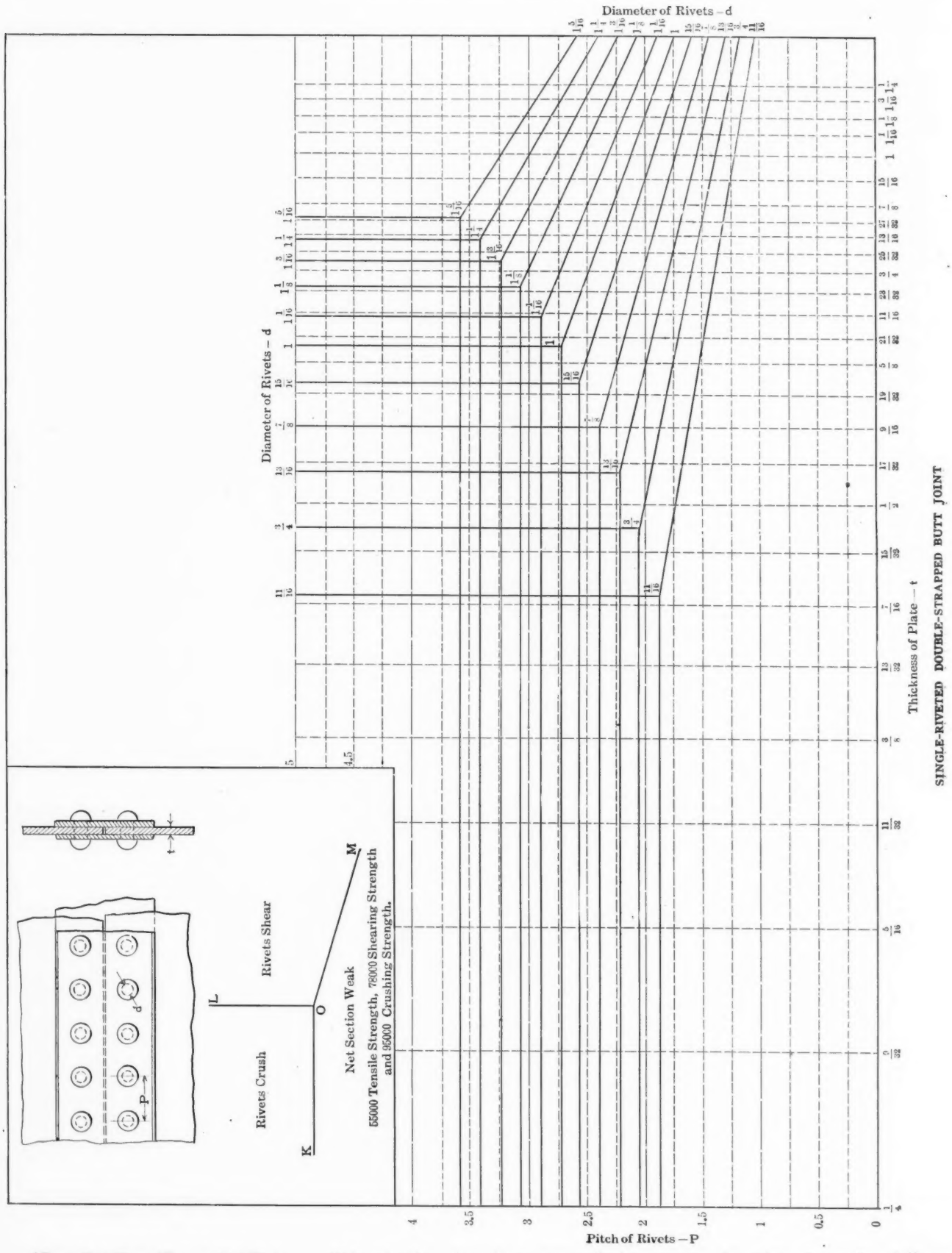
$$(A) = (P - d)\ t\ T$$

$$(B) = (P - 2\ d)\ t\ T + 0.7854\ d^2\ s$$

$$(C) = 2\ C\ d\ t + 0.7854\ d^2\ s$$

$$(D) = 2\ (0.7854\ d^2\ S) + 0.7854\ d^2\ s$$

Six combinations are possible with these four equations, and the lines representing them could be plotted on the diagrams at once and the useless portions removed, as was done with the single-riveted lap joint. There is a simpler method, however, of viewing the problem, and that is by making preliminary subdivisions. Considering the two methods of possible failure, as shown by (A) and (B), and making them equal to each other and solving for t, the following result is obtained:



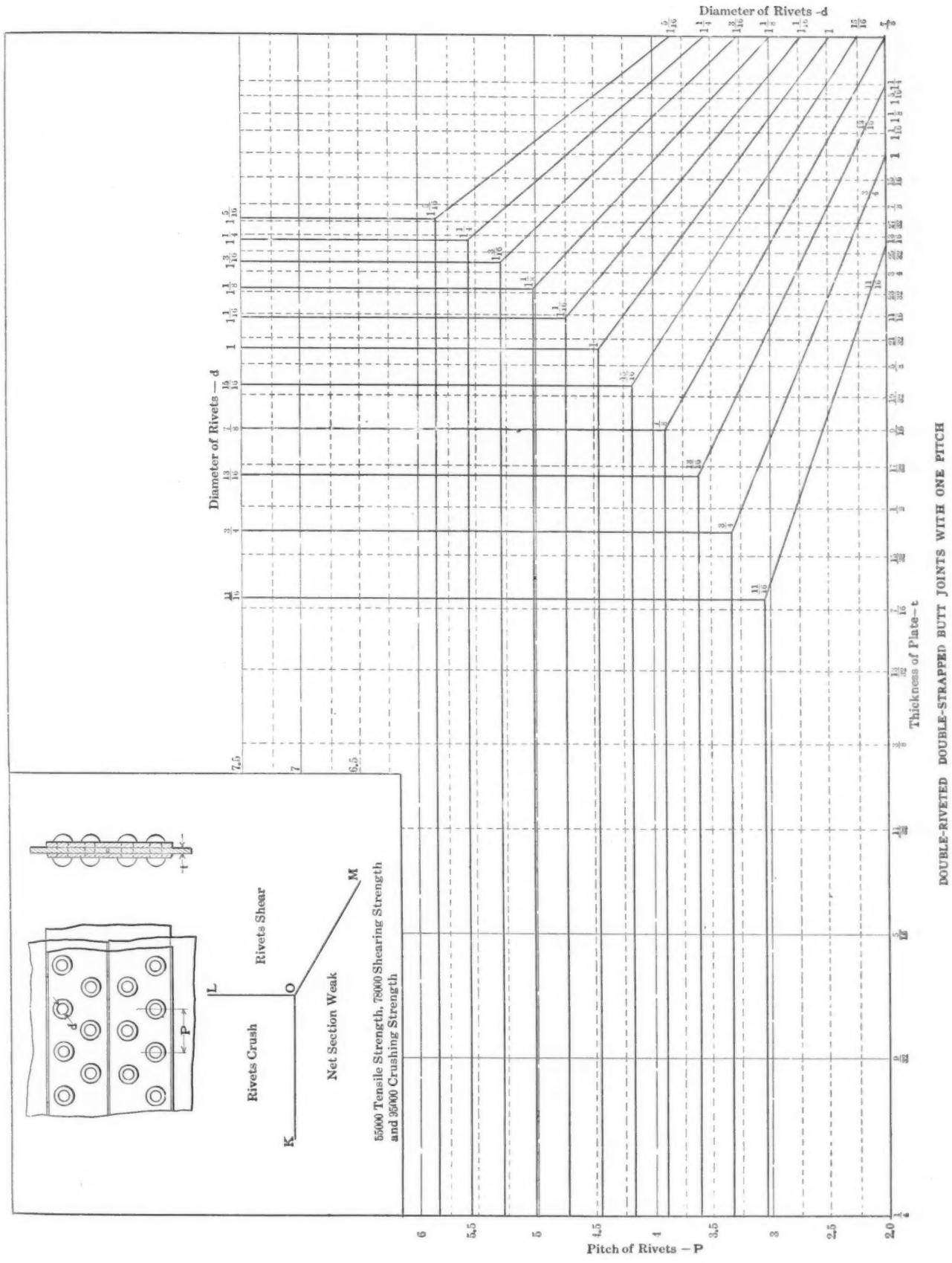
$$(P - d)\ t\ T = (P - 2\ d)\ t\ T + 0.7854\ d^2\ s$$

or

$$t = \frac{0.7854\ d\ s}{T},$$

and when $T = 55{,}000$ and $s = 42{,}000$, $t = 0.6\ d$.

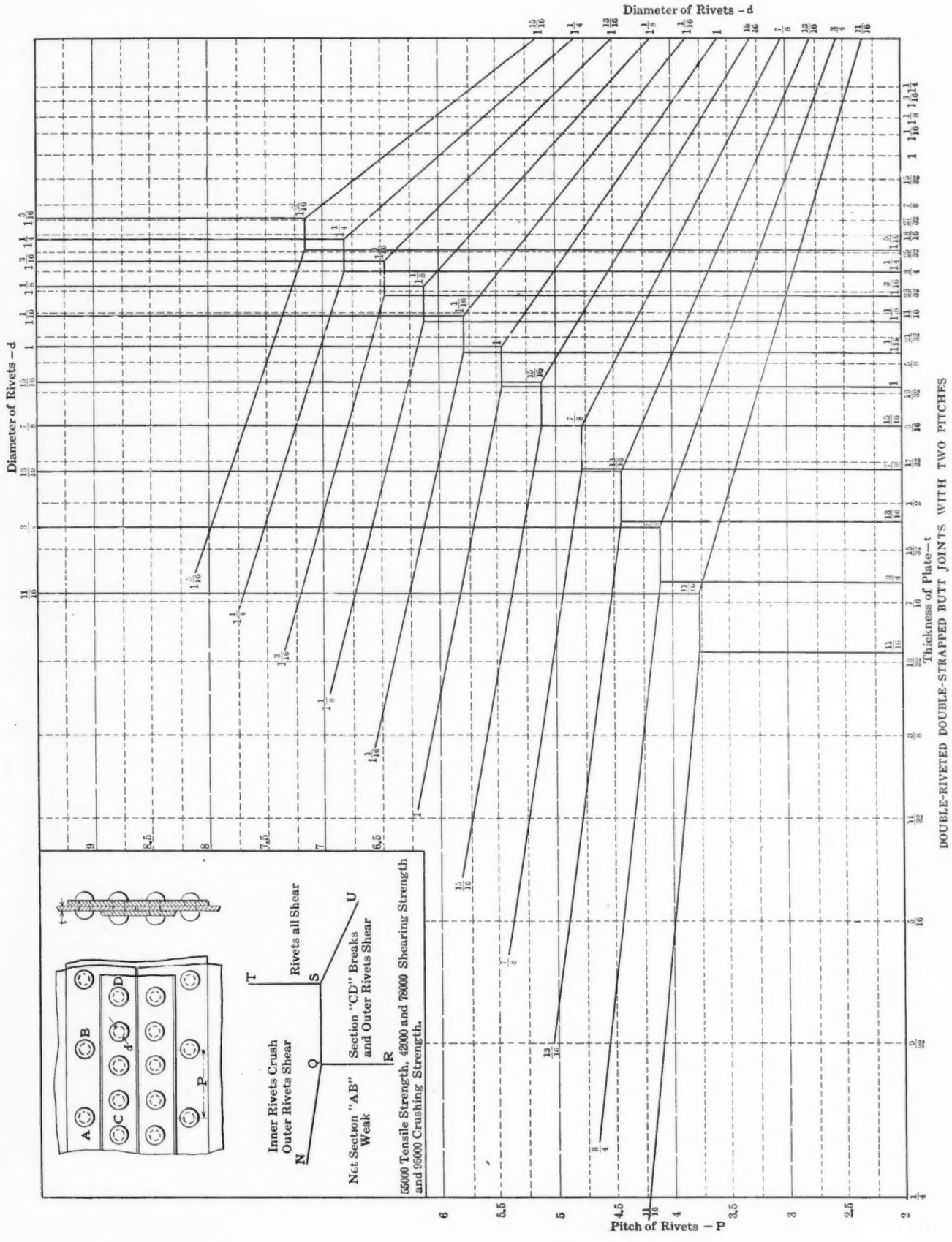
This signifies that if a perpendicular is erected on the axis X at a point, $t = 0.6\ d$, all values to the right of this line would indicate joints which would fail by method (B) rather than (A), for it may be seen from the equations that an increase in the thickness of plate, or t, increases the value of equation (A) more rapidly than equation (B). Therefore for increased values of t beyond the point where (A) and (B) become equal, the joint becomes relatively weaker to resist rupture by method (B). Since this is true, the lines denoting the relation be-



tween the various modes of failure can be plotted in the area to the right of $t = 0.6\,d$, without regard to equation (A).

Noting equations (B), (C) and (D), it is seen that the term $0.7854\,d^2\,s$ is common to them all, so that for the purpose of comparison this term may be dispensed with without affecting the result. Consequently the shearing of the outer rivets in single shear, which this term represents, can be ignored, and the problem of plotting the diagram in the area to the right of the perpendicular $t = 0.6\,d$ becomes identical in every respect to that of a single-riveted butt joint, with the exception that the value of P is twice as great in this case as for the single-riveted joint.

In Fig. 3 the line DE has been drawn at $t = 0.6\,d$, assuming d to be equal to ¾ inch, the values of t being laid off as reciprocals of the thicknesses from the



origin O. The reason for placing the origin at the right is so that increasing values of t could be read from left to right, as this is more natural than the reverse.

Comparing equations (B) and (C),

$$(P - 2d)\, t\, T = 2\, C\, d\, t,$$

and solving for P

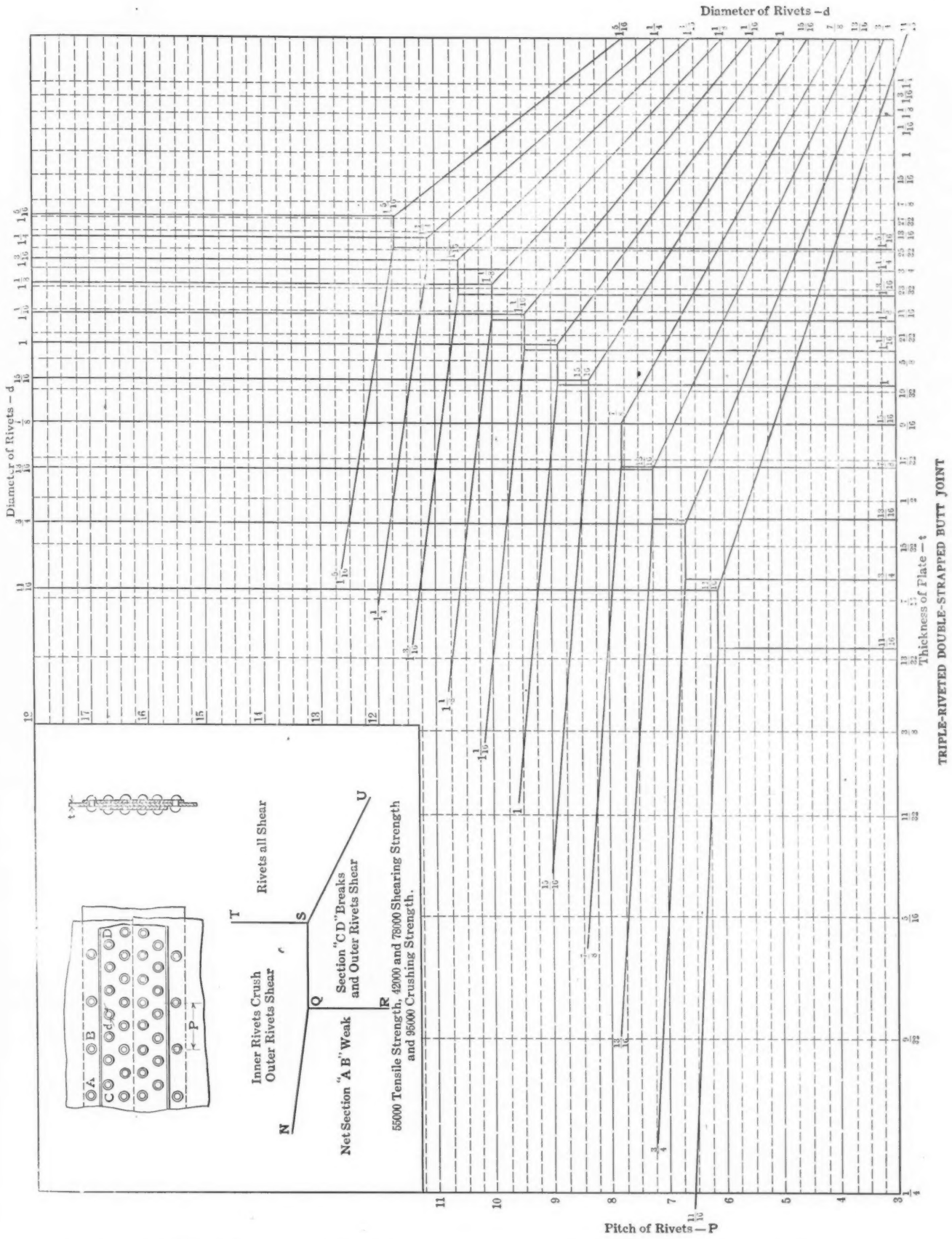
$$P = \frac{2\, C\, d}{T} + 2\, d,$$

or

$$P = 5.45\, d,$$

when $C = 95{,}000$ and $T = 55{,}000$. Line $F\,G$ is drawn at a suitable hight above X to represent this value of P when $d = \frac{3}{4}$ inch.

Comparing equations (C) and (D), the following result is obtained:



$$2\,C\,d\,t = 2\,(0.7854\,d^2\,S),$$

and solving for t,

$$t = \frac{0.7854\,d\,S}{C},$$

or when $S = 78{,}000$ and $C = 95{,}000$

$$t = 0.645\,d.$$

Line $H\,I$ is drawn to represent this value of t.

Comparing equations (B) and (D) and solving for P, the following results are obtained:

$$(P - 2\,d)\,t\,T = 2\,(0.7854\,d^2\,S)$$

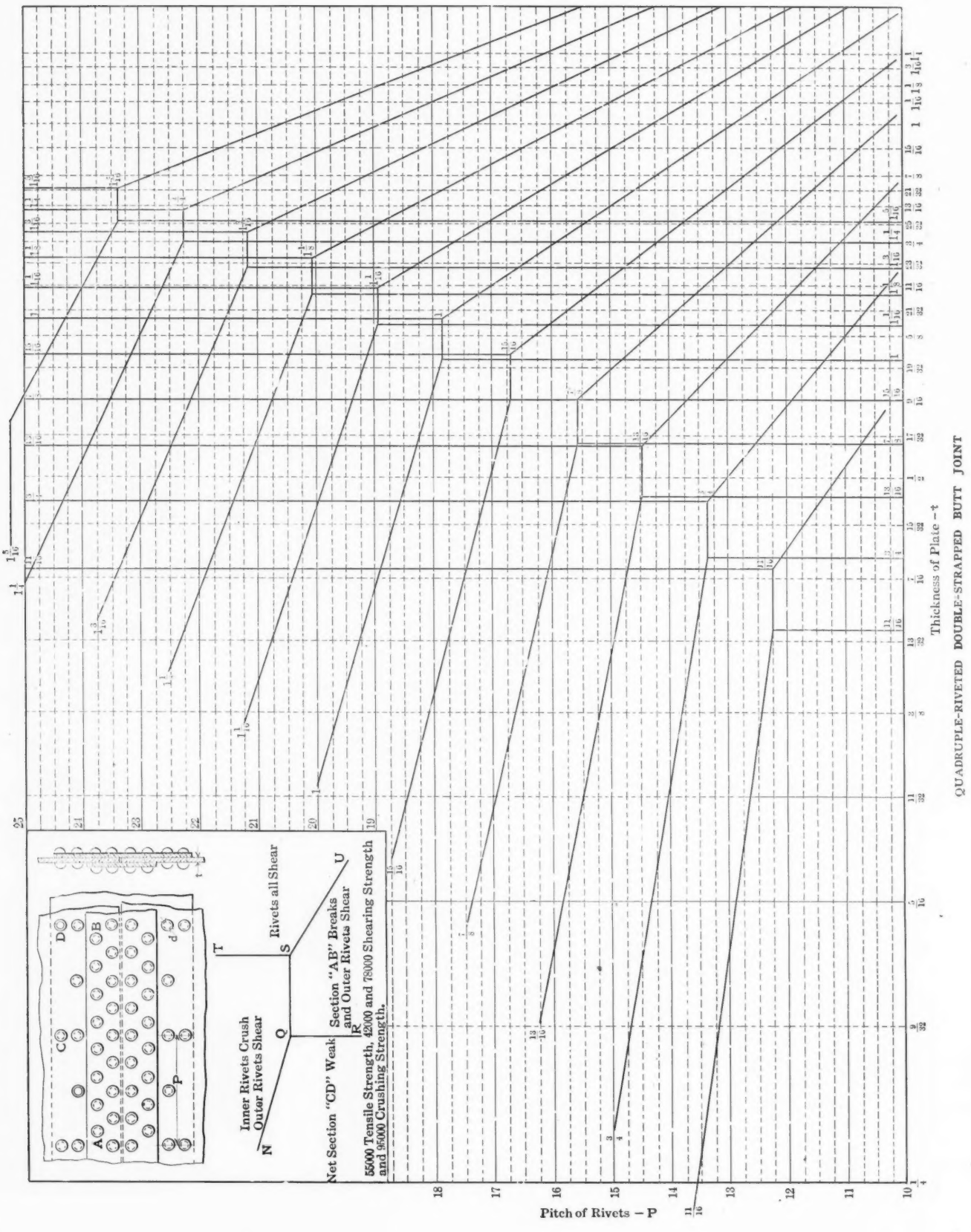
or

$$P = \frac{1.5708\,d^2\,S}{t\,T} + 2\,d,$$

which reduces to

$$P = \frac{2.23\,d^2}{t} + 2\,d.$$

This line cuts the axis Y at a point $2\,d$



above the axis X, or at K in Fig. 3. Another point on this line is at the intersection of $F\,G$ and $H\,I$ at L, and the line $M\,K$, drawn through these points, represents the last equation. For the same reasons explained in describing the construction of Fig. 1, the dotted portions of lines $H\,I$, $F\,G$ and $M\,K$ are superfluous.

Returning to the original equations (A), (B), (C) and (D) to plot the diagram to the left of $D\,E$, the equation (B) is of no further use, since values for it in this area would be high as compared with (A). Now since the line $H\,I$ represents equal values for joint failure by method (C) or (D), and the value of (C) increases or decreases with that of t, while equation (D) is not affected by

variations in t, it is evident that in the area to the left of $H I$, which represents decreasing values of t, that failure by method (D) need not be considered, and since the area to the left of $H I$ also includes all of the area to the left of $D E$, there remains only one comparison to be made to complete the diagram, which is that between equations (A) and (C) as follows:

$$(P - d)\ t\ T = 2\ C\ d\ t + 0.7854\ d^2\ s$$

or

$$P = \frac{2\ C d}{T} + \frac{0.7854\ d^2\ s}{t\ T} + d,$$

or when $s = 42{,}000$, $T = 55{,}000$ and $C = 95{,}000$

$$P = \frac{0.6\ d^2}{t} + 4.45\ d.$$

It will be noted from this equation that when t is given a value of $0.6\ d$, corresponding to line $D E$, Fig. 3, that $P = 5.45\ d$, or is equal to the value of P for the line $F G$. Therefore the point F is one of the points on the line

$$P = \frac{0.6\ d^2}{t} + 4.45\ d,$$

and another point is where it cuts the axis Y at N, which lies $4.45\ d$ above the axis X. It is only necessary to join the points N and F by a straight line extending beyond F as $N P$. The dotted portion of this line $F N$ has no significance, as only comparative values lying to the left of $D E$ are being sought. The diagram is now complete with the exception of explaining that the dotted portion of $D E$ has no bearing on the methods of failure in the area in which it lies, since it represents comparative values between modes of failure, designated by equations (A) and (B), and all values for these equations lying above $P F$ and $F G$ are greater than for (C) or (D).

The line $F P$ is terminated at a value for t which would make the rivets equally as liable to crush or shear, single shear, or in the same position occupied by the vertical lines representing rivet diameters in the lap-joint diagrams, which is

$$t = \frac{0.7854\ d\ s}{C}$$

or $0.347\ d$, when $s = 42{,}000$ and $C = 95{,}000$. The diagram would be correct for all thicknesses of straps or plates above this thickness. For ¾-inch rivets this thickness would be 0.26 inch, or slightly more than ¼ inch; for 15/16-inch rivets and the same values for C and s, this value of t would be between 7/16 and 15/32 inch. It will be found that the proportions between rivet diameters and thickness of plates is such in practical boiler construction that the joints will fall well within the limits of the diagrams. Redrawing Fig. 3 with the dotted portions of the lines omitted, the result would be like Fig. 4, in which the probable method of joint failure is indicated in the different sections of the diagram.

The diagrams for triple- and quadruple-riveted joints are derived in a similar manner to the above, and the equations for the several lines in the three types of joint, are as follows. As before, the letters designating the lines refer to those on the small guide diagram in the upper corner of each sheet.

DOUBLE-RIVETED BUTT JOINT WITH TWO PITCHES

Line Q N:

$$P = \frac{0.7854\ d^2\ s}{t\ T} + \frac{2\ d\ C}{T} + d.$$

Line Q R:

$$t = \frac{0.7854\ d\ s}{T}.$$

Line Q S:

$$P = \frac{2\ C\ d}{T} + 2\ d.$$

Line S T:

$$t = \frac{0.7854\ d\ S}{C}.$$

Line S U:

$$P = \frac{1.5708\ d^2\ S}{t\ T} + 2\ d.$$

TRIPLE-RIVETED BUTT JOINT WITH TWO PITCHES

Line Q N:

$$P = \frac{0.7854\ d^2\ s}{t\ T} + \frac{4\ d\ C}{T} + d.$$

Line Q R:

$$t = \frac{0.7854\ d\ s}{T}.$$

Line Q S:

$$P = \frac{4\ C\ d}{T} + 2\ d.$$

Line S T:

$$t = \frac{0.7854\ d\ s}{C}.$$

Line S U:

$$P = \frac{3.1416\ d^2\ S}{t\ T} + 2\ d.$$

QUADRUPLE-RIVETED BUTT JOINT WITH THREE PITCHES

Line Q N:

$$P = \frac{2.356\ d^2\ s}{t\ T} + \frac{8\ d\ C}{T} + d.$$

Line Q R:

$$t = \frac{0.7854\ d\ s}{T}.$$

Line Q S:

$$P = \frac{8\ C\ d}{T} + 4\ d.$$

Line S T:

$$t = \frac{0.7854\ d\ S}{C}.$$

Line S U:

$$P = \frac{6.28\ d^2\ S}{t\ T} + 4\ d$$

Attention is called to a point in the diagrams for butt joints which is slightly confusing, this being that the values of C, T, s and S, for which the diagrams are constructed, are so related that the lines corresponding to $I L$ and $F E$ in Fig. 3 for ⅞-inch and 15/16-inch rivets come in line with each other, and also coincide with the line for 9/16-inch plate thickness. This line is therefore marked ⅞-inch rivet at the top of the sheet, and 15/16-inch rivet and 9/16-inch plate at the bottom, but with care in the use of the diagrams, when these particular values are required, no trouble should ensue.

To illustrate the use of the diagrams for butt joints with more than one pitch of rivets, suppose that it was desired to know the smallest size of rivet which would be required in a double-riveted butt joint of ½-inch plate and rivets to be pitched 5 inches apart, so that the net section between the outer rows would be the most likely point of failure; placing a pencil point at the intersection of the lines denoting ½-inch plate and 5-inch pitch in the diagram for this joint, it is seen that a rivet 15/16 inch in diameter or greater would be required, and if a ⅞-inch rivet were used in this joint, the crushing of the inner rivets and the shearing of the outer ones would be the weakest mode of possible failure, or if ¾-inch rivets were used, the joint would fail by shearing all rivets. It should be distinctly understood that when the diameter of rivets is spoken of, the diameter after driving or the diameter of the rivet hole is the one referred to.

The Country's Fuel Supply

According to the report, recently made public, of the section of minerals of the National Conservation Commission, the available and easily accessible supplies of coal in the United States aggregate approximately 1,463,800,000,000 tons. At the present increasing rate of production this supply will approach exhaustion before the middle of the next century. From the beginning of coal mining in this country down to the close of 1907 there were mined 6,865,000,000 tons, and it is estimated that for every ton produced half a ton has been lost or wasted; so that the above production represents an exhaustion of the coal supply to January 1, 1908, aggregating 10,200,000,000 tons.

The first step in extending the life of our fuel supply should be to lessen the waste in mining, handling and carriage.

The known supplies of petroleum, natural gas and high-grade phosphate rock cannot be expected to last much beyond the middle of the present century.

One of the advantages incidental to the use of large boiler units is the reduction in radiation per pound of coal burned and of water evaporated.

How to Use Riveted Joint Diagrams*

Thorough Instructions on the Practical Use of the Diagrams, Illustrated by a Complete Set of Examples, with Answers, on Each Type of Joint

BY S. F. JETER

The following explanation and instructions for the use of the diagrams, given in the article on calculating strength of riveted joints, are for those readers who do not care to follow the mathematical reasoning given in connection with the construction of the diagrams, but who wish to use them as an aid in caluculating the strength of such joints.

It is assumed that the article on page 28 of the July number of POWER AND THE ENGINEER, giving the detailed method of calculating the different joints, is thoroughly understood. In that article it was shown that in all joints of either the lap-riveted or the butt-strapped type, in which the rivets were arranged to give only one pitch, there were three possible modes of joint failure; consisting of breaking of the net section of the plate, shearing of the rivets, or crushing of the rivets. It was necessary to find the numerical value of each one of these modes of failure in order to determine which one was the weakest of the three, and the value of this weakest mode of failure was alone used in obtaining the efficiency of the joint.

DIAGRAMS OF SINGLE-PITCH JOINTS

The purpose of the diagrams is to make it necessary to calculate only the weakest mode of failure, as by their aid this may be selected without calculation as follows: Taking the diagram for a single-riveted lap joint for illustration, it is seen that below the drawing showing the type of joint in the upper right-hand corner of the sheet, there is a small diagram which will be known as a guide diagram, consisting of three lines, *OK*, *OL* and *OM*. These three lines represent any similar set of three full lines in the main diagram, which is seen to contain eleven sets, and each set of these lines represents a given rivet diameter, the particular diameter represented being noted at the intersection of the lines, at the upper end of the vertical lines and at the right-hand end of the inclined lines. In addition to the sets of full lines in the main diagram, it will be noted that there are also dotted and dashed horizontal lines and dotted vertical lines, extending across the sheet in each direction; the former represent pitch of rivets in inches and quarters, the numbers at the left-hand side of the sheet giving the value represented by each line. The lines representing even inches are made with long dashes to permit the eye more readily to distinguish them from lines representing half and quarter inches. The vertical dotted lines represent thickness of plate, and the particular thickness represented by each line is printed under its lower extremity.

To determine the weakest mode of failure for a given joint, it is only necessary to find in which section of the diagram, with reference to the full lines indicating the given rivet diameter, the intersection of the lines corresponding to the pitch of rivets and thickness of plate lie, and when this is found the method of failure printed in the corresponding section of the guide diagram is the one sought. It should be remembered that in using the diagrams in this way for a particular size of rivet, that all other full lines representing other sizes of rivets have no significance whatever, and they should be considered as not existing for the time being. Thus with a rivet diameter of 1 inch, all points of intersection between lines denoting pitch of rivets and thickness of plate, lying to the right of the vertical line for 1-inch rivets and above the inclined line corresponding to *OM* of the guide diagram, would denote that joints composed of such pitches of rivets, thicknesses of plate and with 1-inch diameter rivets, would fail by shearing the rivets. Values of pitch and thickness of plate given by lines on the diagram for a single-riveted lap joint (page 00) whose intersections would lie in this area, would be as follows: ⅜-inch plate, and any pitch of rivets of 2¾ inches or more; 13/32, 7/16- or 15/32-inch plate, and any pitch of rivets of 2½ inches or more; ½-inch plate, and any pitch of rivets of 2¼ inches or more, and so on as far as the diagram extends. All joints containing the above relative values of pitch of rivets and thickness of plate, where 1-inch rivets are used, would fail by shearing the rivets.

Intersections of pitch and thickness of plate, which lie in the area corresponding to that marked "net section weak" in the guide diagram, would indicate that this method of failure would be the most likely one in joints constructed with similar values. Such intersections would be for 1-inch rivets, 2½-inch pitch and any thickness of plate up to and including ⅜-inch plate; or 2¼-inch pitch and any thickness of plate up to and including 15/32-inch plate; or 2-inch pitch and any thickness of plate up to and including 19/32-inch plate, and so on. If the intersections lay in the area corresponding to that marked "rivets crush" this would be the most likely mode of joint failure; for 1-inch rivets such values would be represented by any pitch of rivets 2¾ inches or greater and any thickness of plate up to and including 11/32 inch.

From the foregoing it is seen that to calculate the efficiency of any joint, it is only necessary to find in which section of the diagram, with reference to the lines denoting the rivet size, the intersection of lines denoting pitch of rivets and thickness of plate lie, and calculate the value of the particular mode of failure printed in the corresponding section of the guide diagram, and divide this by the value found for the strength of the solid plate. The result is the true efficiency of the joint.

For example, assume a single-riveted double-strapped butt joint, in which the rivets are ¾ inch diameter and pitched 2¼ inches apart, and a plate thickness of ⅜ inch. By referring to the diagram for this type of joint, it is seen that the intersection of the lines corresponding to 2¼-inch pitch of rivets and ⅜-inch thickness of plate, lies in the area (with respect to the lines denoting ¾-inch rivets) corresponding to that marked "rivets crush" in the guide diagram. Therefore, the efficiency would be

$$\frac{\textit{Diameter of Rivets} \times \textit{Thickness of Plate} \times 95{,}000}{\textit{Pitch of Rivets} \times \textit{Thickness of Plate} \times 55{,}000};$$

or since the thickness of plate is common to both numerator and denominator, it would cancel out, leaving

$$\frac{¾ \times 95{,}000}{2¼ \times 55{,}000} = 57.6$$

per cent. efficiency.

If the other methods of failure had been considered, the results would be as follows: Breaking of net section, 62.2 per cent. efficiency; or for shearing of the rivets, 74.2 per cent. efficiency, and since these two latter values are higher than the first, the method of failure indicated by the diagram gives the true efficiency of the joint.

It follows that since the lines representing rivet diameters, which correspond to *OM* in the guide diagram, lie between the area denoting shearing of the rivets, or the breaking of the net section of the plate, that where the lines for thickness of plate and pitch of rivets intersect on this line, joint failure is equally liable by

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either method. For example, the line corresponding to *O M* for $1\frac{1}{8}$-inch rivet diameter (in the diagram for single-riveted lap joints) apparently passes through the point of intersection of lines denoting 2½-inch pitch and 15/32-inch plate, and if a joint of this type should be constructed with these dimensions, it would be as likely to fail by breaking the net section of the plate between the rivet holes, as by shearing the rivets, and the value of either of these methods of failure might be used in obtaining the efficiency of the joint. Calculating the value of the two modes of failure would result as follows: For shearing of the rivets,

$$0.8866 \times 42{,}000 = 37{,}237$$

pounds, and for the strength of the net section of the plate,

$$(2\frac{1}{2} - 1\ 1/16) \times 15/32 \times 55{,}000 = 37{,}061$$

pounds. It is seen that there is a difference of 175 pounds in these two values, and if the diagram was made to a larger scale and absolutely accurate, the line for 1 1/16-inch rivet would be seen actually to pass above the intersection of lines for 15/32-inch plate and 2½-inch pitch of rivets. However, the diagrams are sufficiently accurate for all practical purposes, for when using the shearing strength of the rivets in obtaining the joint efficiency, it is found to be 57.77 per cent., while by using the strength of the net section of the plate, it is 57.5 per cent., so that practically it would make no difference which method of failure was used in the calculation.

If any value of thickness coincided with a vertical line for rivet diameter, it would indicate that the value of the crushing strength of the rivets or their shearing strength could be used indiscriminately in obtaining the efficiencies of joints made with this thickness of plate and diameter of rivet, where the rivets were spaced so that the lines indicating the pitch crossed the vertical line indicating rivet diameter. There is no thickness of plate shown on the diagram for single-riveted lap joints, which actually coincides with any line representing rivet diameter, the lines for 13/16-inch rivets and 9/32-inch plate coming the nearest. The actual thickness which would exactly coincide with the vertical line for 13/16-inch rivets would be 0.28213 inch, and with this thickness of plate and 13/16-inch rivets, and any pitch 2¼ inches or greater, the joint efficiency could be obtained by using the value of either the crushing or shearing of the rivets, as the value of both would be the same and less than the strength of the net section of the plate between the rivet holes.

If any horizontal line denoting pitch of rivets should coincide with a horizontal line for any rivet diameter, a joint consisting of this particular size of rivet and pitch would have an equal value for joint failure by crushing the rivets or breaking the net section of the plate for any thickness which crossed the horizontal line indicating the rivet size. For example, in the double-riveted double butt-strapped joint with one pitch (page 00), $1\frac{1}{8}$-inch rivets were used and pitched 4¾ inches apart, any thickness of plate up to and including 21/32-inch thickness, would give a joint which would be as likely to fail by the rivets crushing as by the breaking of the net section of the plate, and therefore either could be used in estimating the strength of the joint.

It follows from the foregoing that if the thickness of the plate and the pitch of the rivets were such that the lines which would represent them should intersect at the same point as those denoting any rivet diameter (as *O* in the guide diagram), a joint constructed of these values for pitch of rivets, thickness of plate and diameter of rivets, would be likely to fail by either of the three methods of joint failure and this would also represent a joint of maximum efficiency. In the single-riveted lap joint, values of 2¼-inch pitch, 9/32-inch plate and 13/16-inch rivets, come very near fulfilling these conditions, although the crushing strength of the rivets is a little the weakest mode of failure.

The instructions for the use of the diagrams given thus far apply to all forms of joint, both lap-riveted and butt-strapped, in which only one pitch to the rivets occurs, and it will be noted that the diagrams for all these joints are alike in form.

Joint Diagrams with Two or More Pitch Values

The following instructions are for the use of the diagrams constructed for the butt-strapped type of joint in which two or more pitches of rivets occur. The general principles for the use of the diagrams are the same as for single-pitch joints, that is, the area in which the intersection of lines denoting pitch of rivets and thickness of the plate lie, determine the weakest mode of joint failure as indicated by the guide diagrams, and if the intersections happen to fall on the lines indicating the rivet diameter for the given joint, either of the modes of failure noted in the adjacent areas may be used in determining the efficiency of the joint.

Taking the diagram for the triple-riveted butt joint for illustration, it is seen that it differs from the first diagrams in that the full lines denoting rivet diameter divide the space into four sections instead of three, and, as shown by the guide diagram, the two top areas denote joint failure by crushing of the inner rivets and shearing the outer rivets, or the shearing of all the rivets. The two lower areas indicate joint failure by breaking of the outer net section between the rivet holes, or the breaking of the inner net section and the shearing of the outer rivets.

It will be seen that the lines indicating rivet diameters, corresponding to the line *N Q* of the guide diagram, do not extend to the left-hand side of the sheets, except in the case of the 11/16-inch rivet. The explanation for this is, that for mathematical reasons it is required that the two methods of joint failure in which the crushing of the rivets in the outside rows is involved for this type of joint, be eliminated, leaving only the four modes of failure, as shown in the guide diagram. This could be accomplished by making the diagrams apply only to joints in which the thickness of plate and straps are such that the lines indicating the plate thickness cross, at some point, those indicating the rivet diameter used. For example, in joints in which ⅞-inch rivets are used, the diagrams would hold good for thicknesses of plate or straps of 5/16 inch or more, but not for thicknesses less than 5/16 inch. If $1\frac{5}{8}$-inch rivets were used, the plate and straps must be 15/32 inch or more, and so on, the last vertical line to the left indicating plate thickness, which crosses the full line representing the rivet diameter, being the minimum thickness of plate or straps for which the diagrams are constructed. This limit to the range of the diagrams will not interfere with their usefulness in the least, for the range covered includes all practical boiler joints.

The rivet sizes to which each set of full lines apply are given at the extremities of the vertical lines and the angular lines, and also at the intersections corresponding to the point *S* in the guide diagram. Using a ¾-inch rivet for illustrating the use of the diagram for a triple-riveted butt joint (page 00), it is seen that if 7/16-inch plate is used with this size of rivet and the rivets are pitched 6½ inches apart in the outer rows, joint failure would occur by breaking the outer net section; while if the plate thickness had been 15/32 inch, the pitch remaining the same, failure would occur by breaking the inner net section and shearing the outer rivets; if ½-inch plate had been used, the failure would have been equally as likely by the breaking of the inner net section and shearing the outer rivets, or shearing all the rivets both in single and double shear; if 17/32-inch plate were used, the failure would occur by shearing of all the rivets rather than by any of the other possible modes of failure.

If a pitch of 6¾ inches were selected instead of 6½ inches, and 7/16- or 15/32-inch plate used, the failure of the joint would occur by the crushing of the rivets passing through both straps and the shearing of the outer rivets, while if the plate thickness were ½ inch with this pitch, failure would occur by shearing all of the rivets, both in single shear and in double shear.

In using the diagrams to calculate the efficiency of a given joint, it will be found to be most convenient to proceed as follows: Assuming a quadruple-riveted double-strapped butt joint in which the plate thickness is 17/32 inch and the rivets

are pitched 15 inches apart in the outer row, their diameter being 13/16 inch, what would be the efficiency of this joint? Commencing at the bottom of the sheet on the line marked 17/32-inch plate, follow up the line until the horizontal line representing 15 inches pitch is reached hold a pencil or other pointer on the intersection of these two lines, leaving the eye free to locate the full lines indicating 13/16-inch rivet diameter, and it is readily seen that the point upon which the pencil is held lies in the area corresponding to that marked "rivets all shear" in the guide diagram.

After using the diagrams a few times the apparent confusion, caused by the numerous lines representing the rivet diameters, will disappear entirely; however, if it was desired, the reader could retrace the diagrams, placing only a single rivet diameter on each sheet, and the diagrams would then have the same appearance as the guide diagram, with the dotted and dashed lines representing the pitch of rivets and thickness of plate added.

There is one point in connection with the diagrams for double-strapped butt joints with two pitches that should be carefully noted, and that is the line corresponding to $Q\,R$ of the guide diagrams, for 15/16-inch rivets, coincides with the one corresponding to line $T\,S$ for 7/8-inch rivets, and therefore the portion lying between the intersection marked 7/8 inch up to the next set of full lines representing 15/16-inch rivets belongs to both rivet diameters, and it also represents throughout its entire length 9/16-inch plate thickness. It will be observed that the correct rivet diameter represented by the upper portion of the line is placed at the top of this sheet, while that represented by the lower portion is placed at the bottom, so that by using these figures to locate the lines, rather than those given at the intersections of the lines given in the center of the diagrams, when 7/8- or 15/16-inch rivets are used, confusion will be avoided.

It should be thoroughly understood that the diagrams shown are only correct for a tensile strength of plate of 55,000 pounds per square inch, shearing strength of rivets of 42,000 pounds per square inch for single shear and 78,000 pounds per square inch when in double shear, and 95,000 pounds per square inch crushing resistance of the rivets. When rivet diameters are spoken of, the driven diameter of the rivet or the diameter of the rivet hole is referred to.

A feature of the quadruple-riveted double-strapped butt joint, which was not brought out in the July 7 article, may be properly mentioned here. This is, that the failure of this type of joint by the breaking of the plate along the second row of rivets and shearing the rivets in the outer row need not be considered, because it can never be weaker than both the failure by breaking of the outer net section and that of breaking the inner net section and shearing the rivets in the two outer rows, but its value will always lie between these two. Consequently when they become equal to each other, it also is equal to them. Thus, if the line indicating the plate thickness for a given joint of this type should coincide with the line corresponding to $O\,R$ for the rivet size used in the joint, failure would be equally liable by either of the three methods, but for all other values of thickness of plate, one of the two latter methods would be the weaker of the three. As may be seen from the diagram, a joint of 9/16-inch plate and 15/16-inch rivets, with any pitch up to and including 16½-inch, would render failure equally liable by either method.

EXAMPLES FOR PRACTICE

The following questions and answers will be found a convenient aid in becoming familiar with the use of the diagrams. The answers are given separate from the questions, but both are numbered alike, and the reader may write his own answers to the questions and then compare them with the answers given, and in this way test his ability to use the diagrams correctly. Eight questions are asked for each type of joint; the first five relating to the use of the diagrams in obtaining joint efficiencies, and the three last to illustrate other uses for the diagrams.

Single-riveted Lap Joint

What method of joint failure should be compared with the strength of the solid plate to ascertain the efficiency of the following joints?

(1) 3/8-inch plate, 2½-inch pitch and 1-inch rivets.

(2) 13/32-inch plate, 2½-inch pitch and 1-inch rivets.

(3) 7/16-inch plate, 2½-inch pitch and ¾-inch rivets.

(4) 7/16-inch plate, 2¾-inch pitch and 15/16-inch rivets.

(5) 5/16-inch plate, 2¾-inch pitch and 15/16-inch rivets.

(6) What is the smallest rivet diameter that could be used, if the pitch were 2¼-inch and plate thickness 9/32-inch, to insure that the joint would fail by breaking the net section of the plate?

(7) If a joint were made with 13/16-inch rivets and 7/16-inch plate, what would be the smallest pitch of rivets that would cause the joint to fail by shearing the rivets?

(8) With $1\frac{1}{16}$-inch rivet diameter, what thickness of plate would make failure by crushing the rivets impossible?

Double-riveted Lap Joint

What would be the weakest mode of failure for the following joints?

(1) 11/32-inch plate, 3-inch pitch and ¾-inch rivets.

(2) 19/32-inch plate, 3-inch pitch and 1-inch rivets.

(3) 5/8-inch plate, 2½-inch pitch and 7/8-inch rivets.

(4) 7/16-inch plate, 2¾-inch pitch and 11/16-inch rivets.

(5) 13/32-inch plate, 2¾-inch pitch and 13/16-inch rivets.

(6) With 5/16-inch plate, what is the smallest pitch and diameter of rivets which would cause joint failure by crushing the rivets?

(7) With 17/32-inch plate and 13/16-inch rivets, what would be the longest pitch that could be used and insure that the joint would fail by breaking the net section of the plate between the rivet holes?

(8) With 7/8-inch rivets, what pitch would be required if the crushing of the rivets was to be one of the possible methods of joint failure? What thickness of plate would this method of joint failure hold good for?

Triple-riveted Lap Joint

What method of joint failure would be most likely in the following joints?

(1) 3/8-inch plate, 3-inch pitch and 11/16-inch rivets.

(2) 11/32-inch plate, 3-inch pitch and 1-inch rivets.

(3) 23/32-inch plate, 3¼-inch pitch and 15/16-inch rivets.

(4) 23/32-inch plate, 3¼-inch pitch and 1-inch rivets.

(5) 13/32-inch plate, 3¼-inch pitch and ¾-inch rivets.

(6) Would it be practical to design a joint with values for rivet diameter and thickness of plate as given in the diagram, in which failure would occur by crushing the rivets?

(7) What would be the least pitch shown on the diagram that would cause joint failure by crushing the rivets, if the plate thickness was ¼ inch and the rivet diameter ¾ inch?

(8) With 21/32-inch plate and 11/16-inch rivets, what would be the least pitch that would cause the rivets to shear?

Single-riveted Double-strapped Butt

What method of joint failure should be compared with the solid plate, in estimating the efficiencies of the following joints?

(1) 3/8-inch plate, 2½-inch pitch and ¾-inch rivets.

(2) ½-inch plate, 2-inch pitch and ¾ inch rivets.

(3) ½-inch plate, 2¼-inch pitch and 13/16-inch rivets.

(4) 21/32-inch plate, 2¼-inch pitch and ¾-inch rivets.

(5) ¾-inch plate, 3-inch pitch and 1-inch rivets.

(6) There are only two possible modes of joint failure for all thicknesses of plate and rivet diameters shown on the diagram up to and including 7/16-inch plate. What are they?

(7) How would all joints with 7/8-inch rivets and 2½-inch pitch or over fail, if the plate thickness were 9/16-inch?

(8) Would rivets crush in any joint made of plate 17/32-inch or over, if the rivet diameters were not over 13/16-inch?

Double-riveted Double-strapped butt Joint with One Pitch

What would be the most likely mode of failure in the following joints?

(1) 19/32-inch plate, 3¾-inch pitch and ⅞-inch rivets.

(2) 7/16-inch plate, 3-inch pitch and 11/16-inch rivets.

(3) 17/32-inch plate, 3¼-inch pitch and 1 1/16-inch rivets.

(4) 7/16-inch plate, 3½-inch pitch and ¾-inch rivets.

(5) ¾-inch plate, 4-inch pitch and 13/16-inch rivets.

(6) For any thickness of plate up to and including 21/32-inch, and where 1 1/16-inch rivets are used and pitched 4¾-inch apart, what would be the most likely mode of failure?

(7) If the thickness of the plate were not over 7/16-inch, could joint failure occur by shearing the rivets for any rivet size shown on the diagram?

(8) If 1-inch rivets were used in a joint, what would be the lightest plate that would cause the shearing of the rivets to be a possible mode of joint failure?

Double-riveted Double-strapped Butt Joint with Two Pitches

What would be the weakest mode of failure in the following joints?

(1) 19/32-inch plate, 4-inch pitch and 1-inch rivets.

(2) 19/32-inch plate, 4-inch pitch and ¾-inch rivets.

(3) 9/16-inch plate, 5-inch pitch and ⅞-inch rivets.

(4) 15/32-inch plate, 5-inch pitch and 13/16-inch rivets.

(5) 25/32-inch plate, 4¾-inch pitch and ⅞-inch rivets.

(6) How would joints fail, having ⅞-inch rivets and pitched 4¾ inches or less and the plate thickness being 9/16 inch?

(7) What would be the maximum thickness of plate, where 1-inch rivets are used, if the breaking of the outer net section must be one of the possible modes of joint failure?

(8) If 15/16-inch rivets were used in 1-inch plate, what would be the least pitch that could cause joint failure by the shearing of all rivets?

Triple-riveted Double-strapped Butt

What would be the probable method of joint failure in the following joints?

(1) ⅝-inch plate, 6¾-inch pitch and ¾-inch rivets.

(2) 11/16-inch plate, 7¼-inch pitch and 1-inch rivets.

(3) 17/32-inch plate, 8-inch pitch and ⅞-inch rivets.

(4) 17/32-inch plate, 7¼-inch pitch and and 15/16-inch rivets.

(5) 11/32-inch plate, 6-inch pitch and 1 1/8-inch rivets.

(6) With 1-inch rivets pitched 7½ inches, what would be the maximum thickness of plate that could be used and have the net section between the outer rows of rivets the weakest?

(7) If 1⅛-inch rivets were spaced 8 inches apart, what would be the thinnest plate that would cause all of the rivets to shear?

(8) With ¾-inch plate thickness and 1¼-inch rivets, how would joint failure occur for any pitch up to and including 11-inch pitch?

Quadruple-riveted Butt Double-strapped Joint

What would be the most likely mode of failure in the following joints?

(1) ⅜-inch plate, 14-inch pitch and 1⅛-inch rivets.

(2) ½-inch plate, 14½-inch pitch and 13/16-inch rivets.

(3) ½-inch plate, 14½-inch pitch and ¾-inch rivets.

(4) 19/32-inch plate, 15½-inch pitch and 15/16-inch rivets.

(5) ⅞-inch plate, 14-inch pitch and 13/16-inch rivets.

(6) If it was required to design a joint with 1⅛-inch rivets pitched 16 inches apart, and have the net section between the rivets of the outer row the weakest, what would be the maximum thickness of plate that could be used?

(7) With a pitch of rivets of 17½ inches, how thick would the plate be to make all rivets shear, when the rivet diameter is 1¼ inches?

(8) What is the thinnest plate to be used with 1⅛-inch rivets, to make failure by the breaking of the inner net section and the shearing of the outer rows of rivets one of the possible modes of joint failure?

ANSWERS TO QUESTIONS

Single-riveted Lap Joint

(1) Breaking of net section.
(2) Shearing of rivets.
(3) Shearing of rivets.
(4) Shearing of rivets.
(5) Crushing of rivets.
(6) ⅞-inch diameter.
(7) 1¾-inch pitch.
(8) Any thickness of ⅜-inch or over.

Double-riveted Lap Joint

(1) Shearing of rivets.
(2) Breaking of net section.
(3) Shearing of rivets.
(4) Shearing of rivets.
(5) Either shearing of rivets or breaking of net section.
(6) 4¼-inch pitch and 15/16-inch rivet diameter.
(7) 2¼-inch pitch.
(8) 4-inch pitch or over; any thickness up to and including 9/32 inch.

Triple-riveted Lap Joint

(1) Shearing of rivets.
(2) Breaking of net section.
(3) Shearing of rivets.
(4) Breaking of net section.
(5) Either breaking of net section or shearing of rivets.
(6) No, because the least possible pitch would be too great to admit of a tight joint.
(7) 4¾-inch pitch.
(8) 2-inch pitch.

Single-riveted Double-strapped Butt

(1) Crushing of rivets.
(2) Either shearing of rivets or breaking of net section.
(3) Crushing of rivets.
(4) Shearing of rivets.
(5) Shearing of rivets.
(6) Crushing of rivets or breaking of net section.
(7) Either by crushing the rivets or shearing the rivets, both methods of failure being equal.
(8) No.

Double-riveted Double-strapped Butt Joint with One Pitch

(1) Either breaking of net section or shearing of rivets.
(2) Breaking of net section.
(3) Breaking of net section.
(4) Crushing of rivets.
(5) Shearing of rivets.
(6) Either crushing of rivets or breaking of net section.
(7) No.
(8) 21/32-inch plate.

Double-riveted Double-strapped Butt Joint with Two Pitches

(1) Breaking of outer net section.
(2) Shearing of all rivets.
(3) Crushing of inner rivets and shearing the outer rivets, or shearing all the rivets.
(4) Crushing the inner rivets and shearing the outer rivets.
(5) Shearing of all rivets.
(6) By breaking inner section and shearing outer rivets.
(7) 19/32-inch plate.
(8) 4-inch pitch.

Triple-riveted Double-strapped Butt

(1) Shearing of all rivets.
(2) Breaking of inner section and shearing outer rivets.
(3) Crushing inner rivets and shearing outer ones.
(4) Breaking of outer net section.
(5) The diagram does not hold good for this combination of rivet diameter and thickness of plate.
(6) 19/32-inch plate.
(7) 1-inch plate.
(8) By breaking outer net section, or by breaking inner section and shearing outer rivets.

Quadruple-riveted Double-strapped Butt

(1) The diagram does not hold good for this combination of rivet diameter and plate thickness.
(2) Inner rivets crush and outer rivets shear.
(3) All rivets shear.
(4) Inner section breaks and outer rivets shear.
(5) Rivets all shear.
(6) 21/32-inch plate.
(7) 1⅛-inch plate or over.
(8) 11/16-inch plate.

New Turbine Plant at Allentown, Penn.

An Uptodate Alternating-current Plant with Special Facilities for Handling Coal and Ash and an Ideal Location for Obtaining Water

BY JOHN I. BAKER

On account of the increasing demand for light and power and the inadequacy of their old plant, it became imperative for the Lehigh Valley Transit Company to build a new power station. A site near the old plant was selected, and the location is ideal for the receiving of coal and for obtaining water for condensing and other purposes. The building is of concrete construction, walls, floors and roof, all reinforced with Thacher bar reinforcement, and is 228 feet 3 inches long, 107 feet 6 inches wide and about 60 feet to the apex of the trusses. A concrete division wall extending from basement to roof forms a turbine room 228 feet 3 inches long by 52 feet 4 inches wide, and a boiler room 228 feet 3 inches long by 55 feet 2 inches wide. The concrete walls are 12½ inches thick from sub-base to roof. The columns supporting the trusses are on 18-foot 3-inch centers, and in order to make the building fireproof in all respects, the doors and window frames are of steel, made by David Luptons Sons Company, of Philadelphia. Wire glass is used throughout; the majority of the panes are 14½ inches long and 22½ inches high. A ventilator, 48 feet wide, having louvres on the boiler-room side and pivoted glass sash on the opposite side, extends the full length of the building.

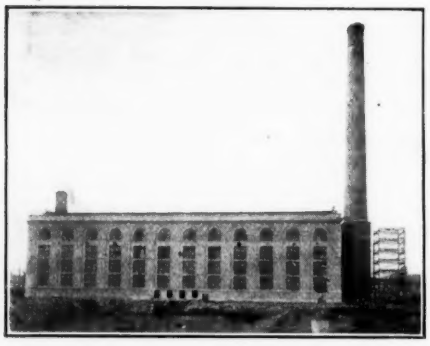


FIG. 1. POWER HOUSE FROM THE LEHIGH RIVER

The Boilers

The boiler equipment consists of ten 525-horsepower Babcock & Wilcox boilers arranged in batteries of two, each battery being 30 feet wide and about 23 feet 5 inches long. A space of 6 feet 6 inches between settings gives ample room for the steam-piping connections to the main header, for operating blowoff valves and for cleaning purposes. The distance from the floor to the top of the steam-outlet flange is 19 feet 9 inches.

Each boiler consists of three drums, 42 inches in diameter and 23 feet 3 inches long, placed above and connected to a set of 21 sections, each section containing 12 tubes 4 inches in diameter and 18 feet long. The drums are three sheets long; each sheet is ½ inch in thickness and all joints are butt-strapped. The superheaters are of the double-loop type; each superheater is made up of 42 groups of four 2-inch seamless drawn-steel tubes and contains 1100 square feet of heating surface. The boilers are guaranteed to evaporate 10½ pounds of water per pound of dry coal from and at 212 degrees Fahrenheit, the coal to contain 14,800 B.t.u. Each boiler contains 5242 square feet of heating surface. The original tubes were hot-drawn and made of No. 10 gage, but on account of occasional rupture, all replacements have been made with No. 9 gage, cold-drawn tubes.

The boilers are equipped with Roney stokers, driven by two 4½x4-inch Westinghouse standard engines. As there is space provided for two additional boilers, the stoker engines are so located that each engine will eventually drive the stokers for six boilers. The line shaft operating the stokers is 1 15/16 inches in diameter and makes four revolutions per minute. An auxiliary engine of the same make is in reserve, and the exhaust from both engines is utilized at the heaters.

Natural draft is furnished by an Alphons Custodis radial brick stack, located directly north of the boiler room, having an octagonal base and an internal diameter of 14 feet at the base with a taper to 8 feet at the top. The total hight of the stack is 226 feet above the foundation, or about 207 feet above the stokers. At the rear of the boilers is a brick flue 9 feet wide and 14 feet high, having an internal area of 126 square feet. Throughout its entire length the flue has these same dimensions. A steel-plate damper is controlled by a Collins damper regulator. The temperature of the flue gases at the base of the stack is 525 degrees Fahrenheit. Structural supports for a future economizer installation were erected with the building and are located above the main flue.

The plant has been in operation since May, 1908, and during that time the greatest overload in the boiler house occurred one evening when nine boilers, for a period of two hours, were operating on a 43 per cent. overload. At the time of the writing Burrows automatic feed-water regulators were being installed.

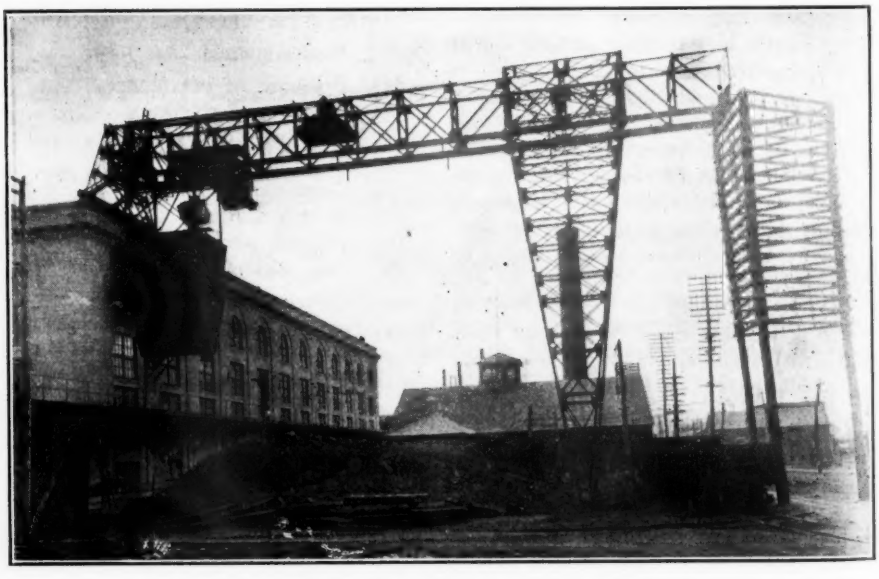


FIG. 2. COAL HANDLING FROM CAR TO PLANT

Coal and Ash Handling

Coal is received by rail, the main line of the Lehigh Valley Railroad Company passing in front of the power house. If

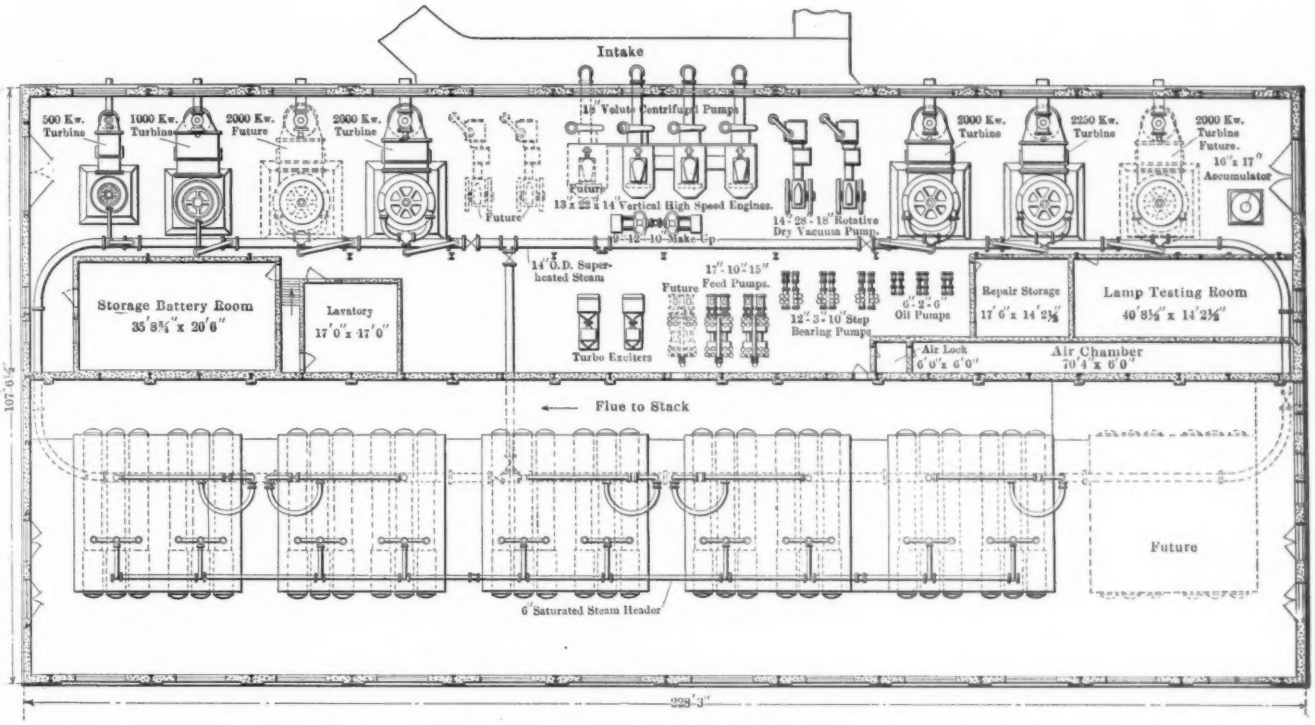

Intake
500 Kw. Turbine
1000 Kw. Turbine
2000 Kw. Future
2000 Kw. Turbine
15" Volute Centrifugal Pumps
Future
13 x 22 x 14 Vertical High Speed Engines.
Future
14" 28" 18" Rotative Dry Vacuum Pumps.
9" 12" 10" Make-Up
2000 Kw. Turbine
2250 Kw. Turbine
2000 Kw. Turbine Future.
16" x 17" Accumulator
Storage Battery Room 35' 8¾" x 20' 6"
Lavatory 17' 0" x 17' 0"
14" O.D. Superheated Steam
Future
17" 10" 15" Feed Pumps.
12" 3-10" Step Bearing Pumps
6" 2-6 Oil Pumps
Repair Storage 17' 6" x 14' 2½"
Lamp Testing Room 40' 8½" x 14' 2½"
Turbo Exciters
Air Lock 6' 0" x 6' 0"
Air Chamber 70' 4" x 6' 0"
107' 0"
Flue to Stack
Future
6" Saturated Steam Header
229' 3"

FIG. 3. GENERAL PLAN OF POWER PLANT

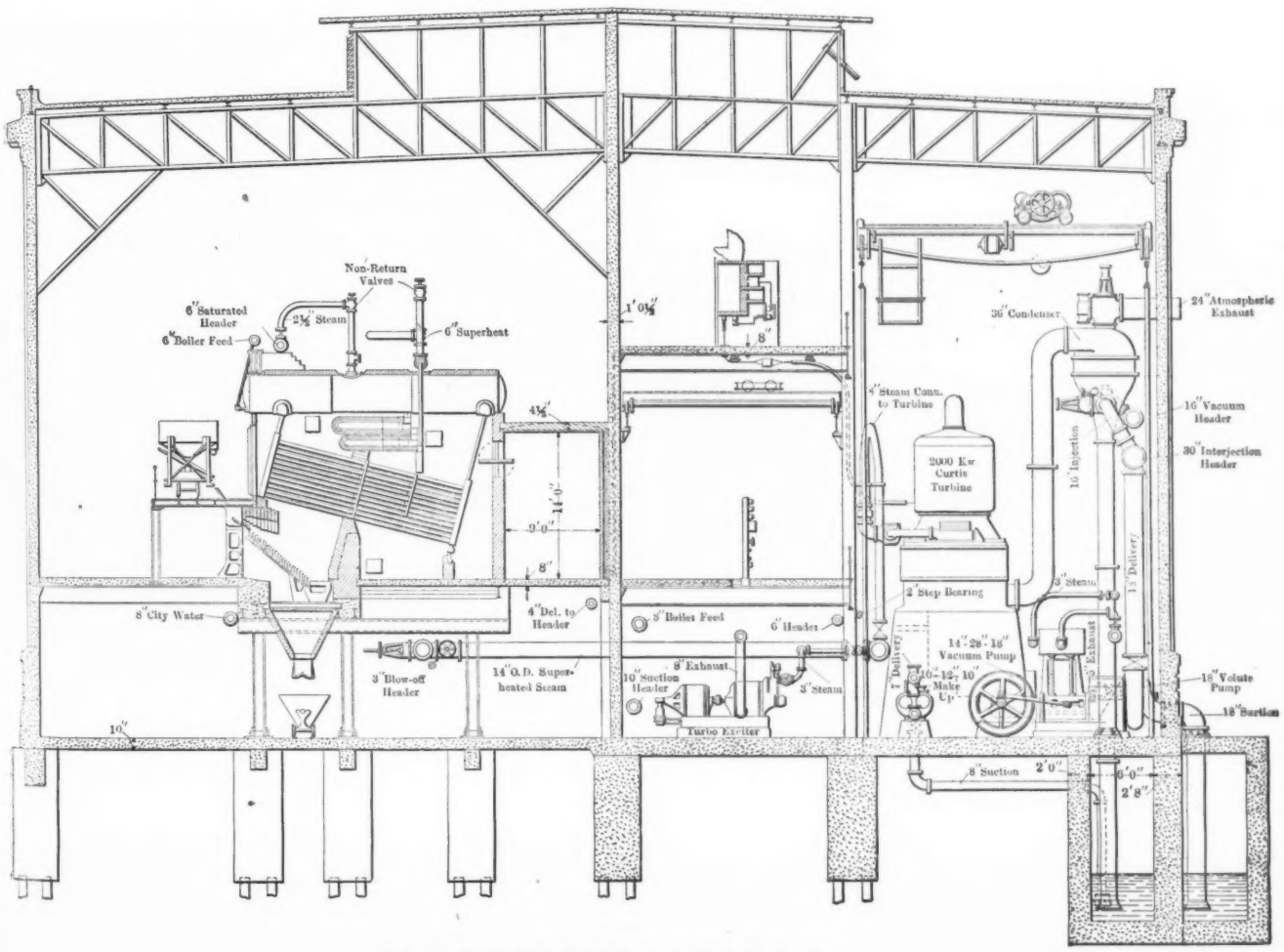


FIG. 4. SECTIONAL ELEVATION OF POWER PLANT

occasion required it, anthracite could be delivered by water, as the Lehigh river and canal are about 500 feet east of the power house. Along Front street there are at present eight reinforced-concrete coal-receiving pits, and the removal of the old power house will give space for three additional pits. Standard-gage railroad cars are run in on a track over a small pit at the side, having a slanting bottom and allowing the coal to slide down into the larger pockets, which are 12 feet wide, 15 feet deep and 19 feet long. Thus the cars can be immediately emptied and returned.

By means of a Gantry crane, built by the Browning Engineering Company, a grab bucket, with a capacity of 2 cubic yards, can take coal directly out of the cars, if necessary, but usually transfers the coal from the large coal pits to a steel-plate hopper attached to the crane, or in the space between the pits and west wall of the boiler room. This hopper will hold about 25 tons, and 6500 tons have been stored in front of the building. One rail for the Gantry crane is along the wall of the coal-receiving pits, while the other rail is supported by a girder at the top of the west building wall. Both rails are 60-pound A. S. C. E. section, and the distance from center to center of the rails is 88 feet 9 inches. One leg of the Gantry crane has a wheel base of 35 feet and the other 24 feet. The crane has a rated capacity of 100 tons per hour.

Extending along the boiler fronts and the west wall of the boiler house, there is a continuous, 19-inch gage track made of 20-pound, standard-section rails. A coal larry, built by the C. W. Hunt Company, and operated by storage batteries, takes coal from the hopper of the Gantry crane and delivers the coal to the small chutes above the stokers. The average capacity of the larry is 5200 pounds. The present coal consumption in 24 hours is from 100 to 125 tons. A bituminous medium-grade Kennerly coal, having the following analysis, is used: Moisture, 1.19 per cent.; volatile matter, 16.41 per cent.; fixed carbon, 70.98 per cent.; ash, 11.42 per cent.; B.t.u. per pound of coal, 13,808.

Motor-driven crushing rolls are located in the large receiving bin attached to the Gantry crane. The operator of the larry fills his car by opening the duplex valves on the hopper, and then runs the car along the front of the building and before entering the boiler room, weighs the coal on a Fairbanks scale having a capacity of 8000 pounds.

In case of accident to the Gantry crane a skip car and hoisting engine, built by the C. W. Hunt Company, have been provided. The skip car empties direct into the larry, and was in use until the Gantry crane was installed. It is now held as a spare.

The ashpits are made of reinforced concrete, and at the bottom of each ashpit there are duplex valves as illustrated herewith. Directly under the ashpits and extending the full length of the boiler-room basement, there is a narrow-gage track, 19-inch gage, made of 20-pound rails. The push-car for handling the ashes has a V-body, 55 inches wide, 40 inches long and 34 inches deep, and is of the double-side dumping type, made by the C. W. Hunt Company. Ashes are used for filling-in purposes, or can be loaded into cars. The narrow-gage track runs up an easy incline to the top of a car. One man takes care of all the ashes and has time to help at other odd jobs.

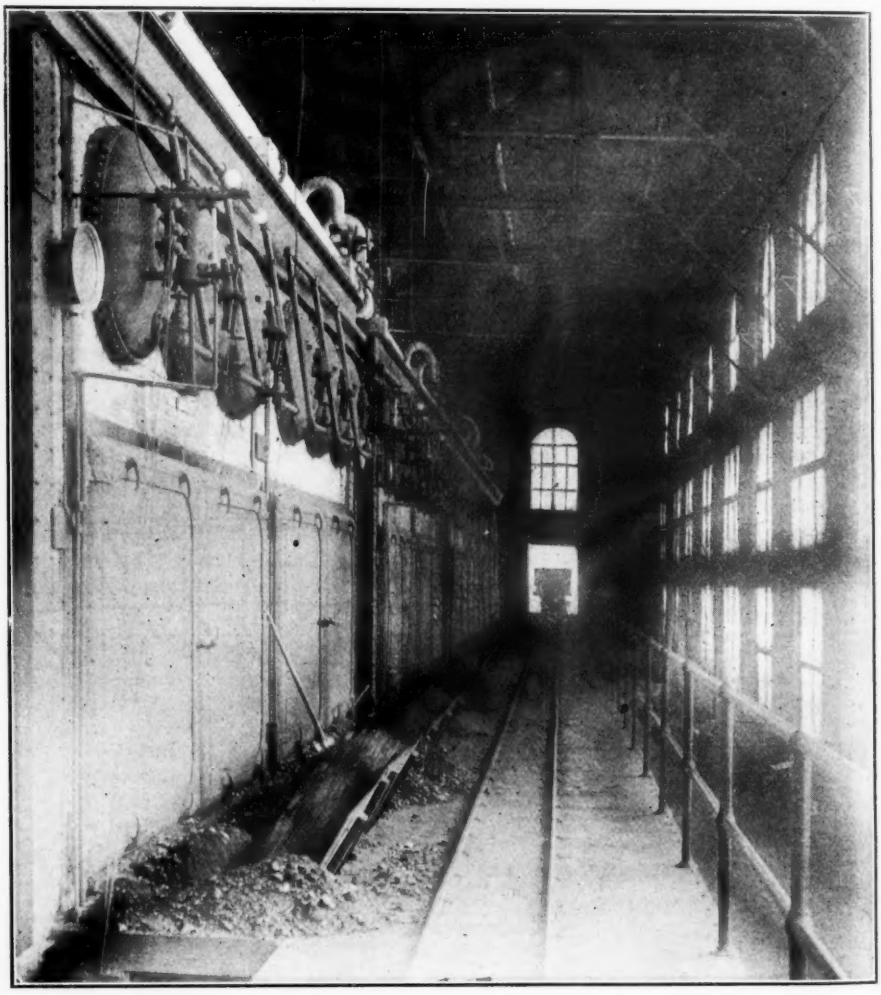


FIG. 5. METHOD OF HANDLING COAL IN BOILER ROOM

Prime Movers

The plant has a nominal capacity of 7750 kilowatts. For railway service there are two four-stage Curtis turbines, each of 2000 kilowatts rated capacity, operating at 750 revolutions per minute and delivering three-phase alternating current at 25 cycles frequency. For lights and motors there are one four-stage Curtis turbine, 2250 kilowatts rated capacity, 900 revolutions per minute; one four-stage Curtis turbine, 1000 kilowatts rated capacity, 1200 revolutions per minute, and one two-stage Curtis turbine, 500 kilowatts rated capacity, 1500 revolutions per minute, these three machines delivering alternating current at 60 cycles frequency.

The old plant consists of four 30x48-inch simple Cooper Corliss engines, running 80 revolutions per minute, each engine having a band wheel 20 feet in diameter and 57 inches face and driving by means of a 48-inch three-ply leather belt a 500-kilowatt Bullock generator. Jet condensers of the Worthington type are installed with each engine. For an emergency in railway service, two of these engines are available.

Condensers and Auxiliaries

All condensers are of the barometric-tube type, made by Henry R. Worthington. By means of a reinforced-concrete intake, 7 feet high and 6 feet wide, water for condensing purposes flows from the Lehigh river, 500 feet away, through the intake and up to and along the eastern wall of the turbine room. Three 18-inch volute Worthington centrifugal pumps take water from the intake through 20-inch suction pipes and discharge into 18-inch pipes into the side of a 30-inch

water header located directly above the pumps and at an elevation of 54.915. The pumps are direct-connected to 13x22x14-inch Bates vertical automatic high-speed engines, running at a maximum speed of 240 revolutions per minute and equipped with Schutte & Koerting Company angle-trip throttle valves.

machine and to 12 inches at the 2250-kilowatt unit. The air connections to the turbine are 4½ inches, 8 inches and 10 inches to the 500-, 1000- and 2000-kilowatt units, respectively.

Since the plant has been in operation trouble has been experienced with injection water coming over into the exhaust

ter. The 8-inch connections to the large turbines are taken from the top of 14x14x8-inch cast-steel tees. No expansion joints are used, the four long-radius 14-inch bends giving flexibility to the line. The saturated-steam header is 8 inches in diameter, with cast-iron extra-heavy screwed flanges and flanged fittings;

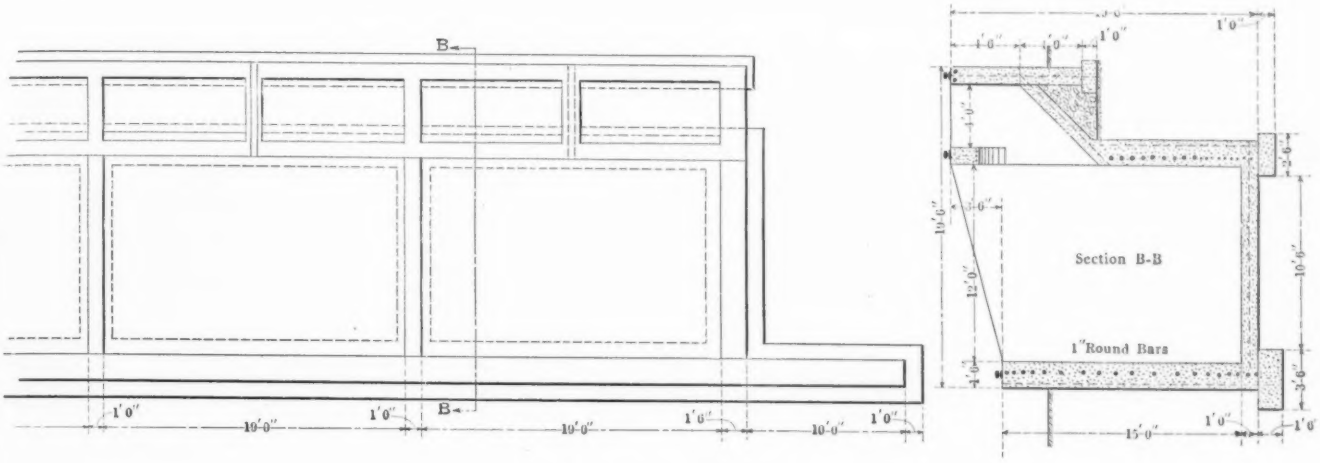


FIG. 6. COAL RECEIVING PITS

The water header extends along the east wall of the turbine room, is supported by brackets attached to the building columns and is 30 inches in diameter where the centrifugal pumps discharge into it, but reduces to 24 inches at the 2000-kilowatt turbine and to 12 inches at the 500-kilowatt unit. From this main header there is a 10-inch injection connection to the 500-kilowatt turbine, a 14-inch injector to the 1000-kilowatt turbine and a 16-inch to the 2000-kilowatt turbine. Ordinary chain passing over

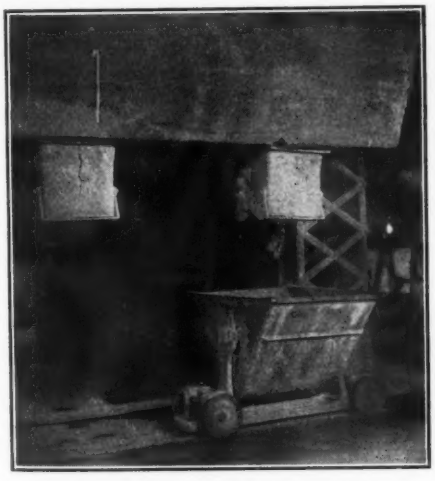


FIG. 7. ASH HOPPER AND CAR

sheaves on the valve stems, and reaching down to handwheels and pedestals on the first floor, allow the attendants to control the injection.

There are two 14x28x18-inch Worthington steam-driven rotative dry-vacuum pumps attached to a 16-inch air header, reducing to 8 inches at the 500-kilowatt

pipe, and in order to put a stop to this make-up pieces 18 inches high have been put in on every condenser. The exhaust connections from the turbine to the condenser are of steel-plate construction with flanges made of steel castings. On the 2000-kilowatt units the rectangular exhaust pipe is 2 feet wide and 8 feet long. The free exhaust pipes are very short, extending just outside of the building wall. Blake automatic exhaust-relief valves of angle type are used on all outfits. Bundy steam traps are attached to the exhaust connections of all turbines and vary in size from No. 101 for the smallest to No. 104 on all of the 2000-kilowatt turbines. A vacuum of 28 inches is maintained. All steam-driven auxiliaries are running non-condensing, the exhaust going to the heaters.

The Piping System

The general arrangement of large steam piping is shown in the plan view of the station. The main steam header is 14 inches in diameter and forms a continuous loop, extending along the turbine room and beneath the boilers. All flanges are of steel and all fittings are steel castings. Van Stone joints are used throughout. The steam is superheated 270 degrees Fahrenheit above the temperature corresponding to 170 pounds gage, which would be 375 degrees, making the total temperature of the superheated line at the boilers 645 degrees Fahrenheit. Copper and steel gaskets have been replaced with an asbestos brand known as "Durabla," obtained from the American Steam Packing Company.

The connections from the boilers for superheated steam are 6 inches in diame-

Chapman extra-heavy gate valves are used and a brand of rubber packing called "Torpedo." Saturated steam is used to operate the centrifugal-pump engines, rotative dry-vacuum pump, feed pump, step-bearing pumps, oil pumps, turbo-exciters and two of the Corliss engines in the old plant. Connections to the saturated-steam header are 2½ inches in diameter. Both saturated and superheated connections are equipped with Schutte & Koerting Company automatic-stop check valves, angle type, with bodies of steel castings.

Feed-water Pumps and Heaters

By means of a 9x12x10-inch Worthington duplex-piston make-up pump, water is taken from the discharge conduit and

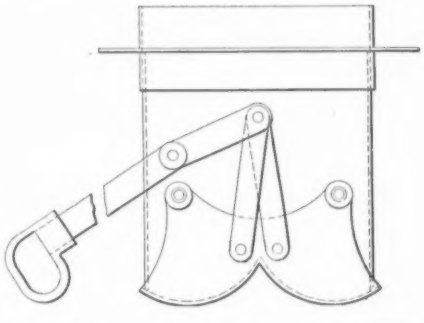


FIG. 8. DUPLEX VALVE FOR ASH HOPPER

delivered to two 4000-horsepower Cochrane feed-water heaters and purifiers located in the basement below the boiler room. There is also a spare pump of the same size connected up as an auxiliary and located as shown in the general-plan drawing. Both pumps are equipped with 2½-inch Fisher pump governors. The

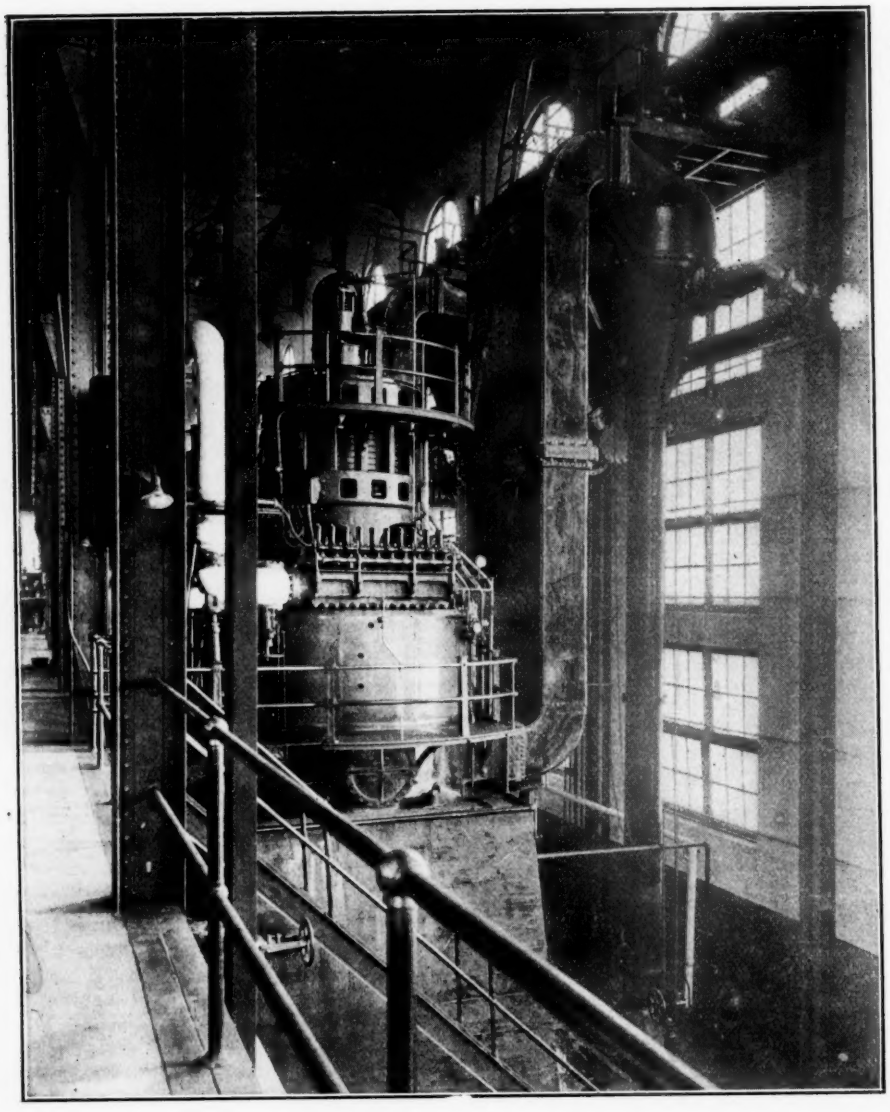


FIG. 9. ONE OF THE 2250-KILOWATT CURTIS TURBINES

feed water, which has a temperature of 208 to 210 degrees Fahrenheit, flows by gravity to two 17x10x15-inch Worthington duplex-plunger feed pumps equipped with Fisher pump governors. The heaters can also take water from an 8-inch connection to the city water line. The boiler-feed header is 6 inches in diameter.

Step-bearing and oil pumps

There are three 12x3x10-inch Worthington duplex-plunger pumps supplying water pressure for the step bearings of the turbines. These pumps are also equipped with Fisher pump governors and so are the oil pumps. The pressure gages show that it takes 200 pounds per square inch for the step bearing of the 500-kilowatt machine and about 435 pounds for the 2000-kilowatt turbine. In case of accident to these pumps a 16x17-foot R. D. Wood & Co. hydraulic accumulator can supply sufficient pressure to keep the turbines running 15 minutes. For oiling the top and middle bearings of the turbines and also the throttles, there are three 6x2x6-inch Worthington duplex-plunger oil pumps.

Electrical Equipment

The two 2000-kilowatt turbine units generate alternating current at 13,200 volts. The old switches between the turbines and buses are located on the second gallery which extends the full length of the power house. To the busbars there are attached five transmission lines as follows: Two on the Philadelphia line, sending 13,200 volts to the substations at Coopersburg, Sellersville, Landsdale and Ambler; one to Siegersville and Slatington, one to Catasauqua and one to Bethlehem and Hecktown.

The southern end of the switchboard gallery contains the substation for the Allentown lines, consisting of nine transformers having a capacity of 185 kilowatts each. The transformers are delta-connected on both high- and low-tension sides, and are air-cooled by two 55-inch Buffalo Forge fans direct-connected to 4-horsepower induction motors running 690 revolutions per minute and guaranteed to furnish 10,000 cubic feet of air per minute at ¾ ounce pressure. At the transformers the current is stepped down to 430 volts. By means of three 25-cycle rotary converters, each of 500 kilowatts capacity and running 500 revolutions per minute, this alternating current is converted into direct current at 600 volts for railway service. The equipments of the other substations are similar to the one just described, with the exception that the voltage is stepped down to 370 volts at the transformers and the converters are of 300 kilowatts capacity each.

For lighting purposes there are three

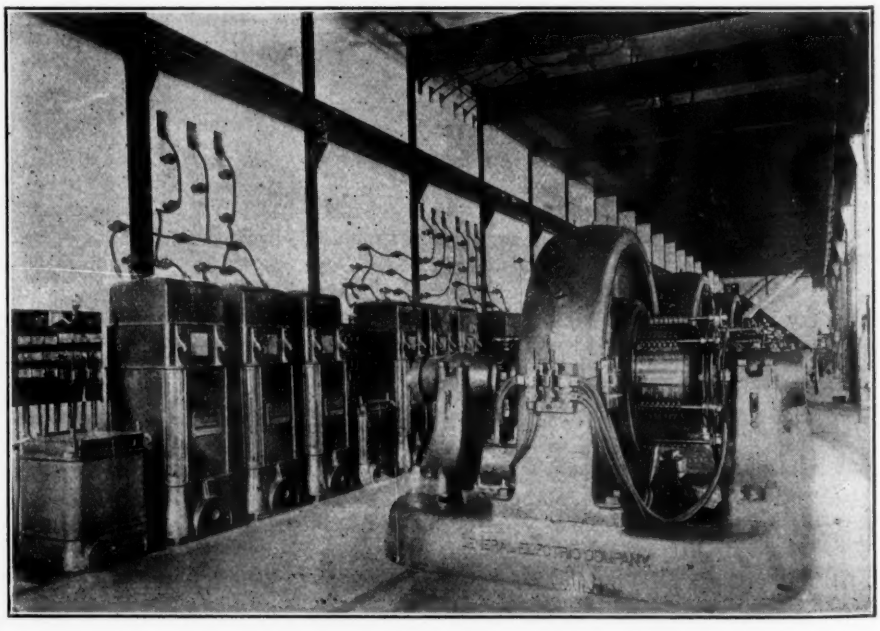


FIG. 10. ROTARY CONVERTERS AND TRANSFORMERS

units of 500, 1000 and 2250 kilowatts rated capacity, generating alternating current at 2300 volts and of 60 cycles frequency. By means of three transformers, each having a capacity of 200 kilowatts, the current is stepped up to 13,200 volts. Transmission lines extend to the towns of Bethlehem and Slatington. A rotary converter of 300 kilowatts capacity and synchronous motors driving arc machines; three generator panels, 60 cycle; two exciter panels, one storage-battery panel, two 2000-kilowatt 25-cycle panels, five 25-cycle 13,200-volt panels, one 300-kilowatt 60-cycle panel for rotary converter, three 500-kilowatt 25-cycle panels for rotary converters, two motor-circuit-feeder panels, one motor-circuit panel,

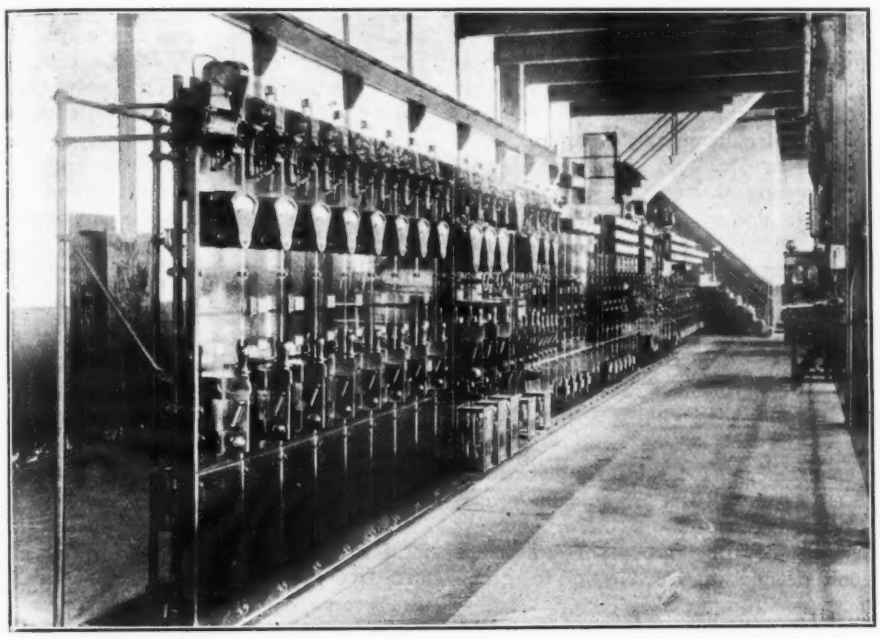


FIG. 11. SWITCHBOARD CONTAINING 57 PANELS

running 900 revolutions per minute converts this current into 600 volts direct current, supplying commercial power and the power for the Gantry crane.

For the 650 arc lamps in Allentown and neighboring towns there are on the second gallery eight Brush arc generators, each having a capacity of 125 lamps. Four 140-horsepower three-phase 2300-volt synchronous motors are direct connected to the arc generators, one motor mounted centrally between two generators.

Exciters and Storage Batteries

On the first floor there are two turbo-exciters operating at 2400 revolutions per minute. These machines are of 75 kilowatts capacity, and one machine can be used as a booster to charge the storage batteries. The storage-battery room, located on the first floor, contains 75 Type G 11 chloride accumulator cells furnished by the Electric Storage Company, and there are always 57 cells floating on the exciter buses.

The switchboard consists of 57 slate panels about 2 inches thick and 7 feet 6 inches high. The total length of switchboard is 81 feet 4 inches and is made up as follows: Ten single-phase feeder panels, 2300 volts; one three-phase panel, 2300 volts; three transmission-line panels, 60 cycle, 13,200 volts; one panel for three 600-volt panels, eight 600-volt-feeder panels and the remainder are extra to be used when future railway generators are added. The voltage at the switchboard is about 120 volts. The electrical equipment throughout the entire plant was furnished and installed by the General Electric Company.

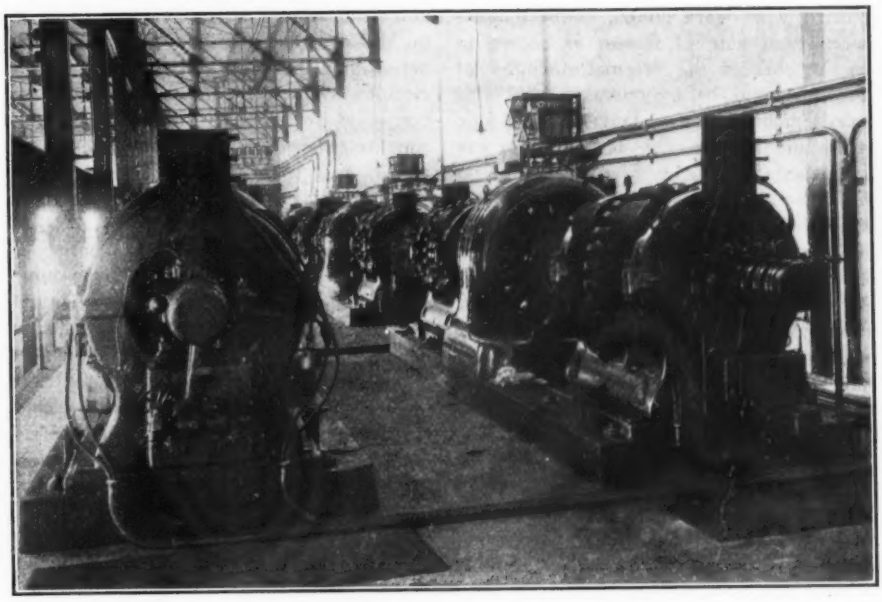


FIG. 12. BRUSH ARC GENERATORS

General

The turbine room is equipped with one 25-ton Case electric traveling crane having a span of about 27 feet from center to center of the rails. The crane girders are supported on 10-inch I-beams, which in turn are attached to the building columns. The western section of the turbine room contains two galleries. The first has office rooms at one end and a substation at the other end, with the switchboard located about centrally. This gallery is served by a hand traveling crane having a capacity of 10 tons. The plant operates continuously and is run on three shifts per 24 hours. The number of men per shift is as follows: One watch engineer, one pumping engineer, one turbine engineer, one operator and helper on the switchboard (helper necessary on account of the substation on the switchboard gallery), one man, nights only, for arc machines on the second gallery, two firemen who are also watertenders, one man for ash handling and one man for coal larry, the crane runner on the Gantry crane, one machinist, one boilermaker and one laborer for two shifts.

The company operates 150 miles of electric railway and recently has inaugurated a trolley express service; three large cars, resembling outwardly the ordinary freight car, will carry freight to all points along the line. The boiler room of the old plant has been made into an express station. Class rates are governed by official steam-road classification.

The plant was designed by the Scofield Engineering Company, Philadelphia, Penn. The writer is indebted to the superintendent of the power house and other employees for their courtesy and help in gathering the data for this article.

The Three-Wire System with One Dynamo

The Reason Why the Neutral Wire Is Necessary. Methods Used for Compensating Unbalanced Load. Size of Motor Compensator Needed

BY CECIL P. POOLE

If an ordinary dynamo be connected to a group of incandescent lamps arranged in series multiple, as indicated diagrammatically by Fig. 1, its voltage will have to be twice that for which each lamp is made; that is, if 110-volt lamps are used, the voltage of the dynamo must be 220 (disregarding line losses for the present). Such a system would be even more economical than the three-wire system, and would have been adopted instead of the three-wire system but for one serious defect—the lamps would have to be installed, lighted and extinguished in pairs. Consequently, a customer who wanted 5 lamps would have to take 6, and he could not control his lamps singly.

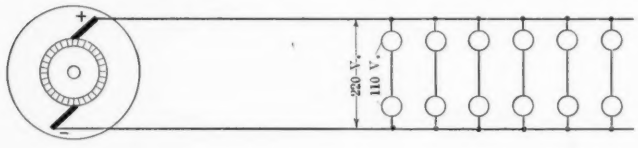


FIG. 1

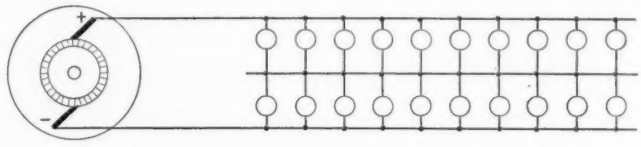


FIG. 2

If, to the arrangement shown in Fig. 1 a third wire were added, connected between each pair of lamps, as shown in Fig. 2, part of the original difficulty of control would be overcome. With this arrangement, any one lamp on one side of the middle wire could be lighted or extinguished, provided one of the lamps on the other side was simultaneously lighted or extinguished. So long as the number of lamps on one side was equal to the number on the other side, it would not matter just which lamps were lighted and which were out. But this would require turning on and off 2 lamps every time, and, worse yet, the consumer would have to know which lamps were on one side and which on the other side of the system, which makes it utterly impractical. The reason for having to keep the same number of lamps lighted on both sides of the same will be evident upon consideration of Fig. 3. Here 10 lamps are shown on one side and 8 on the other. If the resistance of each lamp were 220 ohms, which is a common value for 110-volt lamps, the joint resistance of the group of 10 would be $220 \div 10 = 22$ ohms and that of the 8 lamps would be $220 \div 8 = 27\frac{1}{2}$ ohms. The total resistance of both groups, therefore, would be $22 + 27\frac{1}{2} = 49\frac{1}{2}$ ohms, and the current flowing through the groups would be $220 \div 49\frac{1}{2} = 4.44$ amperes. Now the proper current for the 10 lamps would be $110 \div 22 = 5$ amperes, and the proper current for the 8 would be 4 amperes; consequently, the group of 10 lamps would get too little current and the group of 8 lamps too much.

In order to correct this defect in the arrangement shown, it is necessary to provide means for taking the surplus current from the smaller load on one side and transferring it to the greater load on the other side. This is called "compensating" the lack of "balance" in the circuit. (When the load, or number of lamps on one side of the middle wire is equal to the load on the other side, the circuit is said to be "balanced;" any other condition makes the circuit "unbalanced.") One of the simplest methods of compensating for unbalancing is to connect a secondary battery between the two main wires and connect the middle or "neutral" wire to the middle point of the battery, as in Fig. 4. Here 10 lamps are shown on one side and 6 on the other; the flow of current is indicated by the arrows. Under the conditions shown, the half *A* of the battery will deliver just enough current, if the voltages are suitably proportioned, to supply one-half of the excess or unbalanced load on the heavy side of the system. The dynamo supplies the other half of the excess current, and this half comes in on the neutral with the current supplied by the section *A* of the storage battery and passes back to the dynamo through the section *B* of the battery, charging that section. This proportion holds good for any degree of unbalancing; that is, that part of the battery on the heavily loaded side will send out one-half of the current in the neutral wire and the other half will go through the part of the battery that is on the light load side of the neutral.

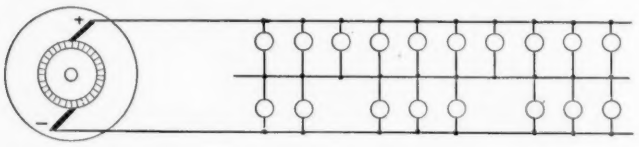


FIG. 3

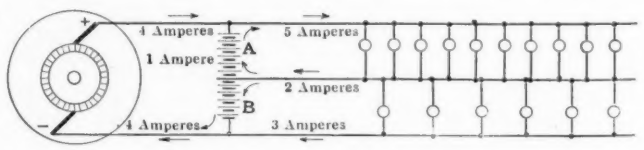


FIG. 4

This arrangement, though apparently ideal in simplicity on paper, is not so attractive in practice because a rather troublesome regulator is needed in conjunction with the battery in order to prevent it from exhausting itself when the load is heavy or drawing too heavily from the line when it is light. Moreover, the two halves of the battery cannot be kept in equal condition, because one side would do more work than the other, unless the circuit could be unbalanced alternately and equally on first one side and then the other. This difficulty can be met, however, by exchanging the two sections at regular intervals, say once a week.

A more practical method of compensation is by means of what is commonly termed a "motor-balancer," but is more correctly a motor-compensator. This consists of two small motors exactly alike in all respects, their shafts rigidly coupled together and their armatures connected one on each side of the neutral wire, as indicated in Fig. 5, where 120 lamps are represented on each side of the neutral wire. Here it is assumed that the motor armatures require one ampere to drive them, or 220 watts (110 watts each), and for simplicity the current required by their field windings is ignored. So long as the load is balanced, the two armatures will take current from the main wires only.

and will revolve idly. If more load is added to one side, however, or some load taken off the other side, the equilibrium between the voltages of the two sides will be upset; the voltage at the brushes of the motor on the lightly loaded side will be higher than that at the brushes of its mate, and it will drive the latter at a speed beyond that due to the circuit voltage, making a dynamo of it, and forcing it to carry the unbalanced part of the heavier load on the circuit. This is illustrated in Fig. 6, where 120 lamps are shown on one side and 60 on the other, each of the circles representing 10 lamps, taking ½ ampere each. What causes the distribution of current shown is this: When the load in the *B* division is reduced the voltage rises, because the losses in the dynamo and circuit wires are reduced; the voltage between the neutral and the negative wires rises more than that between the positive and neutral, because the resistance there is higher—all the reduction of load has occurred in that division of the circuit. The armature *B*, therefore, speeds up, dragging the armature *A* with it until the voltage of the latter increases above that of its side of the circuit sufficiently to carry half of the excess load on that side, minus the power required to drive the two machines. This power was assumed to be 220 watts; the current taken by the two armatures in series in Fig. 5 being one ampere and the total voltage 220. Here, one of the armatures does all the work, so that the whole 220 watts must be applied to it, in addition to an amount of power equal to that being delivered by the armature *A* working as a dynamo. As the armature *B* takes its current now from the unbalanced current coming in on the neutral wire, it works at 110 volts and therefore requires 2 amperes to overcome the losses in the two machines (the losses in the windings are ignored to simplify the problem); the neutral wire must carry 30 amperes because the 60 lamps in the negative division will pass only 30 amperes. Deducting the 2 amperes for motor losses leaves 28 amperes, which divides between the two machines, 14 amperes supplying the motor with the energy necessary to produce 14 amperes from the armature now driven as a dynamo.

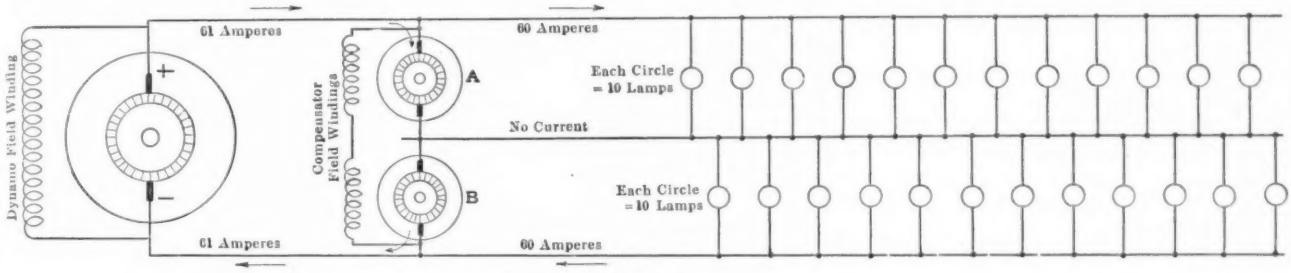


FIG. 5

Another way to arrive at the division of current is as follows: The main dynamo must supply all of the energy represented in the circuit; all that the compensator does is to transfer the surplus energy from one side of the circuit to the other —it cannot supply any additional energy because it is driven by energy taken from the main circuit. Now the lamps take each ½ ampere at 110 volts, or 55 watts; there are 180 lamps, requiring 180 × 55 = 9900 watts. The compensator requires 220 watts to overcome its no-load losses, the extra losses at load being ignored for the present. The lamps and compensator together, therefore, require 9900 + 220 = 10,120 watts. Ignoring line losses, the generator works at 220 volts, and in order to deliver 10,120 watts it must deliver 10,120 ÷ 220 = 46 amperes. Since the lamps in the positive division (*A*) require 60 amperes, the armature *A* working as a dynamo must supply 60 — 46 = 14 amperes. Consequently, of the 30 amperes in the neutral wire, 14 must have been generated in the little machine; the other 16 pass through the motor armature *B* to the main dynamo, as previously explained.

The exact figures in practice would not be those here stated because the line losses, the current in the field windings of the compensator and the losses in their armature windings affect the current distribution. The principle, of course, is not affected; the machine on the lightly loaded side of the system always runs as a motor and drives its mate as a dynamo.

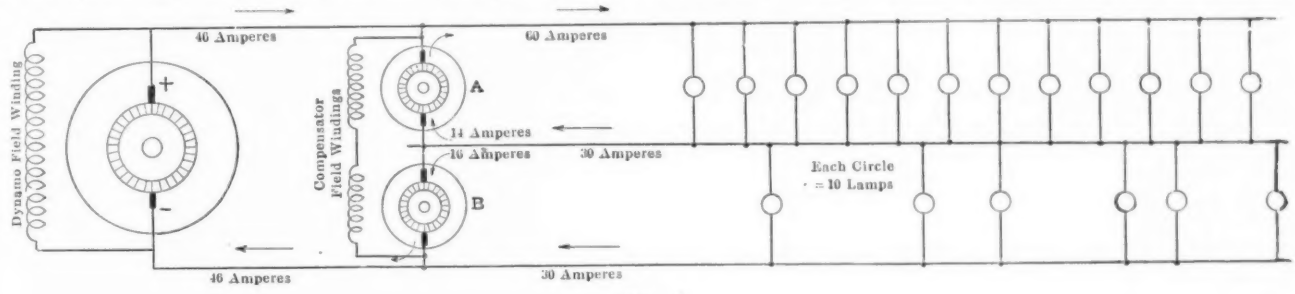


FIG. 6

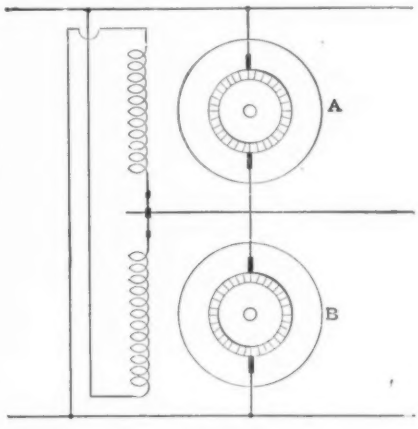


FIG. 7

the latter supplying about one-half of the difference between the two divisions of the load, minus the power required to drive the machine. The losses do affect the voltage regulation, however. If the armature windings of the compensator are of very low resistance, the voltages on each side of the neutral will be kept almost exactly equal; if the armature resistances are high, the voltage between the neutral and the main wire which carries the heavier load will be appreciably lower than that on the other side of the system.

The regulation obtained with motor compensators can be much improved by cross-connecting the field windings, as shown in Fig. 7. The result of this is that when the load on the side *A*, for example, is less than that on the other side, the voltage of the side *A* being higher than that of the side *B*, the field strength of the machine *A* will be weaker than that of the machine *B*, and its speed will be higher than it would be with a steady field. The machine *B*, on the other hand,

driven as a dynamo, will have its field strengthened, and will deliver a higher voltage than it otherwise would. In other words, the machine which runs as a motor runs at a higher speed, giving its mate a higher voltage, and the latter will have a stronger field, augmenting its voltage still more, with the connections shown in Fig. 7 than with the more usual arrangement shown in Figs. 5 and 6. If the resistances of the armatures are made very low, however, the improvement in regulation obtained with cross-connected field windings is not great enough to justify the extra complication involved.

The armature capacity of a motor compensator, in amperes, must be equal to one-half of the current that will flow in the neutral wire when the system is out of balance by the maximum amount possible under operating conditions, plus the current required to overcome *all* losses in the two armatures at full load. The losses in small armatures range from 5 to 10 per cent. at full load; therefore, if the compensator armatures can carry 55 per cent. of the maximum current that will ever flow in the neutral wire, they will be large enough.

Reorganizing an Old Water Power

There are doubtless many plants deriving considerable water power from old developments in which both volume and efficiency could be materially increased by a complete reorganization in accordance with the most recent practice. And not only may the power end be benefited thereby, but the good results there possible of attainment may be considered in conjunction with relocation or reconstruction of the manufacturing building or buildings so as to secure the maximum of convenience and efficiency. A typical case of this nature is presented by a reorganization conducted under the supervision of Charles T. Main, of Boston, which successfully embraced both of these advantages as is evident from the following brief description.

The complete plant of the mill in question formerly consisted of three separate installations, each with its own individual dam, water wheels and buildings, all situated within about 1200 feet. The head of water at each dam varied from 10 to 18 feet, according to the changeable conditions. The improvements started with the elimination of the two down-stream dams and the selection of the remaining up-stream dam for service in the new development. By this combination a total head of 40 feet was obtained. From the up-stream location the water was carried through a steel penstock to a modern and comparatively small water wheel somewhat below the farthest down-stream dam. At this point a new manufacturing plant was erected to take the place of the scattered buildings. In this were incorporated many improvements in the way of manufacturing equipment. The old buildings at the other dams were abandoned or used for storage purposes.

The advantages of the reorganization were evidenced in two ways, by the concentration and utilization of a better-conserved water supply under a greater total head and by the grouping of the manufacturing buildings on a single building site. The expense of upkeep of the three original dams was reduced and limited to that upon one, while the loss of head between them, inevitable under the old conditions, was eliminated. By selecting the up-stream site for the single dam and carrying the water by penstock to the new site at a considerable distance down stream, the maximum head was utilized. It is evident that had the down-stream location been selected and the same head provided at the wheels a new dam would have been required. This would have required extra strength to withstand the greatly increased pressure.

FIG. 1. METHOD OF REINFORCING CONCRETE STACK

The combined power at the best was relatively small, but when divided into three units, as in the original installation, the friction losses were excessive. By the adoption of the new plan it became necessary to keep only one dam tight in order to conserve the water. The excessive leakage through the other two was eliminated, as was also the amount passing by the water wheels during the night. In every way the new plant was more efficient and more easily operated. The power available at the new mill is now sufficient to run the entire plant several months of the year.

Concrete Chimneys

By Ethan Viall

The Illinois traction system, which has a network of interurban electric lines all over central and southern Illinois, has placed concrete stacks at all of its power houses. Up to date eight of these stacks, varying in hight from 160 to 185 feet, have been built or are in the process of construction. These chimneys will average about 12 feet in diameter at the bottom and taper to 10 feet at the top, and are set on a concrete foundation 25 feet square.

Fig. 1 shows one of the chimneys and the entire construction gang, including boss and inspector. The method of reinforcing is well shown in this cut. In addition to the upright rods shown, a ⅝-inch round iron hoop is placed outside of the verticals every 18 inches, and all are firmly imbedded in the concrete. At the bottom are placed 144 uprights, and the number is gradually reduced to 12 at the top.

It will be remembered that one of the chimneys built by this company at Peoria fell with disastrous results, the cause being said to be that the concrete mixture was allowed to stand too long before being placed. Since this accident occurred, quick placing of the mixture and rigid inspection has been the rule. Fig. 2 shows one of the chimneys at the end of the fourth week's work.

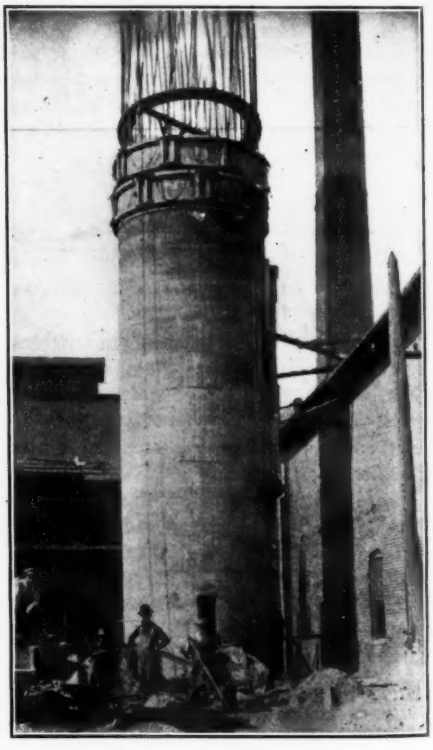


FIG. 2

Supernatural Visitation of James Watt

An Entertaining Presentation of What the "Father of the Steam Engine" Might Do and Say if He Were to Come Back to Earth Today

BY WARREN O. ROGERS

There are many subjects upon which men do not agree, some even going so far as to ridicule the beliefs or opinions of others, although they themselves have never investigated their truth or falsity.

I have no apologies to make for the wonderful experiences I have had with matters which to many may seem supernatural, I shall not attempt to convince anyone that it is possible to communicate with those who have departed this world and passed into the Great Beyond, but will content myself by merely relating my experiences and leave the reader to form his own opinion.

For years I have been a student of psychical research. I have not been content to confine myself to the foolishness of knocking on doors and tipping tables, but have harmonized my mental powers with the influence surrounding many departed spirits. Therefore, astonishing as it may seem, I have been able to enter into the state in which they exist, to some extent, and although possessing my earthly faculties I also partake of their spiritual life, and can see those with whom I am talking, although in phantom form, and converse with them in my own tongue.

The most interesting of these experiences have been those of communing with men whom the world now regard with honor, although dead and buried for many years. These experiences have been most interesting because no living man can tell of their earthly life, and many an hour have I spent in congenial conversation with James Watt, George Stevenson, Robert Fulton, and others. I mention these particularly because I am interested in the subjects they were familiar with more than any others.

My first experience with a resident of the other world was accompanied by sensations not altogether pleasant. I sat one evening, deeply absorbed, reading a scientific treatise on the subject already mentioned. I was alone, and the stillness of the house was broken only by the frequent gusts of wind and rain beating against the window panes. Thus passed the hours. As the clock on the mantel chimed midnight, I closed my book, with the intention of retiring, but, instead, fell to musing as to what such a man as James Watt would say if he could return and view with mortal eyes the great strides made in the en-

I SHALL NEVER FORGET THE APPEARANCE OF JAMES AS HE SAT, ONE SHADOWY LEG OVER THE OTHER, THE FRAGRANT CIGAR SMOKE ASCENDING IN WAVY COLUMNS FROM HIS THIN, BLOODLESS LIPS

gineering field since he left us. Absorbed in such speculations, a power which had been developing in me for some months began strongly to assert itself, and being willing to assist, I focused my entire mental energy to bring into my presence in a tangible form that long-departed inventor to whom the world owes so much.

My first realization that another presence was with me was a faint shadow between the light and the wall. It was not a human form, and yet it was. While I gazed, I was seized with a sensation of extreme cold—fear it may have been, I know not. I tried to speak, but my lips were speechless. I tried to move, but was powerless. To add to the horror, the electric lights began to grow dim; the fury of the storm without increased, and a nameless dread possessed me. The form advanced slowly toward a vacant chair on the opposite side of the table. The deep chilly atmosphere of the grave seemed to permeate the room, and as I felt the cold, clammy hands of my visitor grasp my own, my overtaxed mind could stand no more, and I fell into a state of unconsciousness. When I regained my faculties, I heard a friendly voice say:

"Do not be disturbed; you have long wanted a visit from me, and on my part I have been just as anxious to converse with you."

As my vision grew clear, I saw that the one I had been longing to bring into my presence was indeed with me. His genial, smiling face and pleasant voice soon put me at ease, dispelling all sense of fear of the supernatural (which, I may state, has never returned).

In order to make James feel at home, I asked him what he would have, and being told a Scotch high-ball, proceeded to concoct the same, which speedily disappeared. Having thus fortified ourselves, and being comfortably seated in our chairs with fragrant Cuban "perfectos" in our mouths, I asked James to tell me about his early struggles, a subject I was not entirely familiar with.

I shall never forget the appearance of James as he sat by my library table; one shadowy leg over the other, the silver buckles on his low-cut shoes glistening in the rays of the electric light, the half-empty glass on the table (for I had refilled it again), and the fragrant cigar smoke ascending in wavy columns from his thin, bloodless lips.

"I was born," said he, "of poor but, honest parents—"

"Stop, James, stop where you are! I did not ask you to recite the beginning of one of Laura Lean Jibby's novels. I asked you to tell me something that can't be bought on every newsstand in the country. Now, start again."

He recrossed his legs, took another sip, and said in a somewhat dogged tone, I thought:

"Well, they were poor, anyway."

I nodded my approval, and he continued:

"My ancestors were all mechanics and men of genius, so you see it is nothing strange that I was endowed with an inventive turn of mind, or that I lived 150 years before my time. I was born, as you have doubtless heard, at Greenock, Scotland, January 19, 1736. It was a bitterly cold day, and father was so chilled he could hardly measure out oatmeal to his customers. He was a merchant on a small scale. He had lost all his money speculating; that is the reason I always had to work for a living. [Here James gave a sigh of regret.]

"I was a slim, puny kid up to the time I got to knocking up against the world, and then it kept me so busy looking after the £.s.d., I didn't have time to worry about my lack of muscle, and, as a consequence, I picked up."

"I don't care anything about your health, James," said I. "How about your sitting beside the fire speculating on the tea kettle and all that?"

James grinned and winked one eye at me, as he said:

"Don't you take any stock in that yarn. In those days we had the open fire-place, the crane, tea kettle, and all that. The weather in Scotland at that time—I don't know how it is now—was moist, cold and disagreeable at certain seasons of the year, and would pretty near freeze a fellow to a frazzle. [James is evidently a Republican.]

"The back of the room would be like an iceberg, while near the fire one got the other extreme. After I had been out for a few hours cutting up devilments, finishing the chores and eating my bowl of porridge, I felt like sitting near the fire to keep warm. As a general thing an iron tea kettle was hung on the crane to heat water to wash the supper dishes, and as I didn't have anything else to do, I used to sit and watch the steam come out of the cover and spout of the tea kettle, or look at the fire; but as for sitting there and figuring on getting up a steam engine, don't you think of it for a minute, my boy. I was toasting my shins, nothing more. After I improved on the steam engine and got so prominent that people were willing to give me half the sidewalk when we met, some old woman remembered me sitting before the fire toasting my shins and started the tea-kettle story." And James laughed long and loud.

I began to take a fancy to James, for I could see that he was not going to take any more credit to himself than he deserved, and he was proving a pretty jolly companion. Seeing him cast a longing gaze at the cigar box, I pushed it toward him, with an invitation to help himself, which he did. After attempting to light the fresh cigar on the electric-light bulb and evidently much astonished at his inability to do so, he said:

"When I left home I went to London, and became apprenticed to an instrument maker named Morgan. I could stand him only about a year when I skipped out and went back to Scotland, where I hobnobbed with a lot of college professors repairing their kits. Next, I tried to open an instrument-making shop in Glasgow, but the union wouldn't stand for it, seeing I had not served my apprenticeship, although to tell the truth it would have taken a mighty good man who had done better or more accurate work than I did. They thought they were 'it,' but you don't hear much about them now, do you?" And I thought I could notice a slight chestiness about James I hadn't seen before.

"However," he continued, "I was helped along by the college professors, and after awhile found myself established in the college with the cognomen of Mathematical Instrument Maker to the University. What do you know about that? The professor knew I could make instruments, while the practical man thought I was no good, because I had not worked four years for some skinflint for next to nothing while learning my trade." James spoke with considerable vehemence, I thought, considering the occurrence had happened a century and a half ago.

"While at college I made the acquaintance of some pretty learned men and dabbled in philosophy, anatomy, chemistry, electricity, etc. It was my interest in philosophy which caused me to turn my attention toward old Newcomen's engine. I met him only the other day," said James after a pause, "and he swears that he had worked out my scheme of condensing steam, but had been bothered in getting his ideas through the patent office, both at home and abroad, when I butted in. What do you think of that?" James looked at me inquiringly, but before I could answer said:

"Newcomen is only doing what others have done. Few give me credit for what I have accomplished, most people saying that my work consisted of improving what others had started, but I see that they still hold to a lot of my ideas. Now wouldn't that press your pants?"

"Tell me about your first attempt at a condenser," I said, as James flicked the ashes from the end of his cigar with his little finger.

"I am afraid I shall be obliged to postpone that for another visit, as I am not yet advanced enough in the circle of progress in my world to warrant my roaming around on earth during daylight hours, and as it is almost sunrise I shall soon be obliged to bid you 'good morning.' We have had a jolly good time though, haven't we? I'll be only too glad to come back whenever you feel like putting up with such a cold-blooded old fellow as I am."

James arose, and as he reached across the table to shake hands the morning sunlight streamed in through the eastern window, and my visitor of the night immediately faded from my sight.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

A Study in Flexibility

The accompanying illustrations show two dry-vacuum pumps, *E* and *F*, connected to so-called "centrifugal barometric" condensers. While this arrangement is apparently simple, it caused no little discussion as to the best means of making the pumps interchangeable on either condenser. A "centrifugal barometric" condenser is a jet condenser of the barometric type, and differs only in that the vacuum is created not by the fall of a column of water but by the suction of a centrifugal pump. Its chief advantages are in the saving of head room and the avoidance of long connections.

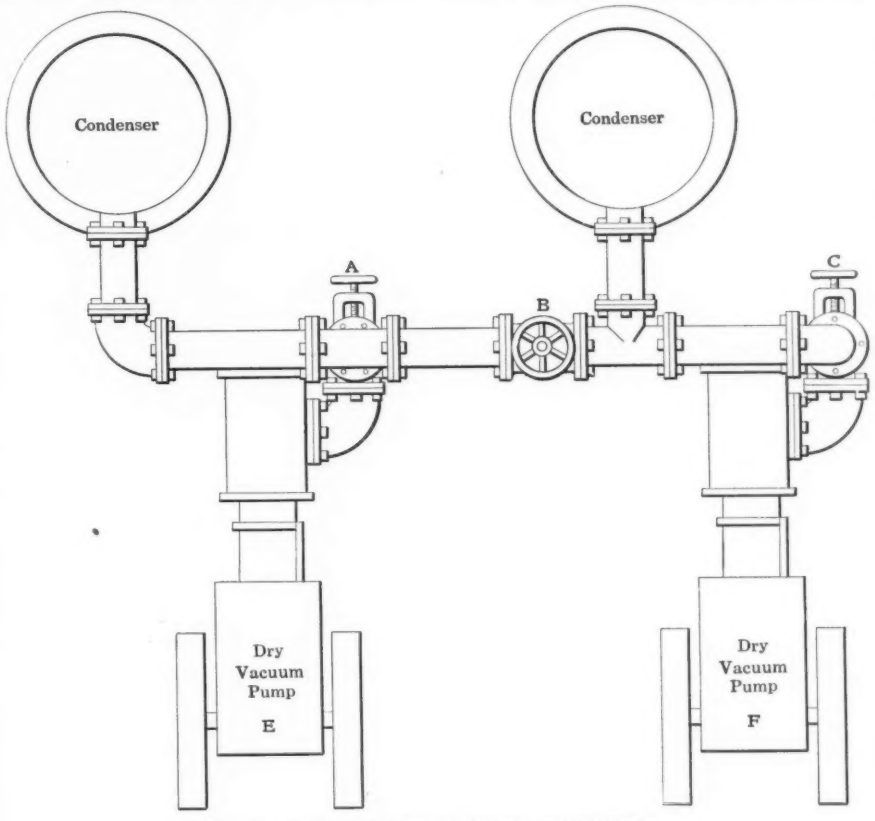


FIG. 1. SHOWING THE ORIGINAL CONNECTIONS

Fig. 1 shows the piping as originally laid out, without any particular thought of interchangeability; therefore, it is difficult to understand why the valve *B* was placed in the line and, in fact, why the connections for the two units were not made entirely separate. As the sketch shows, a valve was placed in the drop leg to each vacuum pump; the valve *B*, therefore, could hardly serve any useful purpose except to separate the horizontal run into two parts.

Even had it been desired, by opening *B* and closing *C*, to allow the left-hand pump to operate with the right-hand condenser, the vacuum would still be placed on the left-hand condenser, and even though the valve in the exhaust from the engine, the circulating-water valves, the priming-water valves and the drain valves on the left-hand condenser were all closed, the numerous joints would afford an opportunity for sufficient air to leak in to cut down the vacuum on the right-hand condenser.

When piping has been erected it is much easier to find out mistakes, and in this case it was seen that with comparatively few changes the arrangement could be made much more flexible. Fig. 2 shows how it was done. The valve *B* was removed from the main run, and placed in the short connection between the tee and the condenser; another valve *D* was placed similarly on the other condenser. Then by closing *A* and *D*, the right-hand pump operates with the right-hand condenser; closing *B* and opening *D* the left-hand condenser is put in commission. The left-hand pump and condenser may be operated separately by closing *B* and *C* and the left-hand pump operated with the right-hand condenser by closing *D* and *C*.

GEORGE W. MARTIN.

Pine Bluff, Ark.

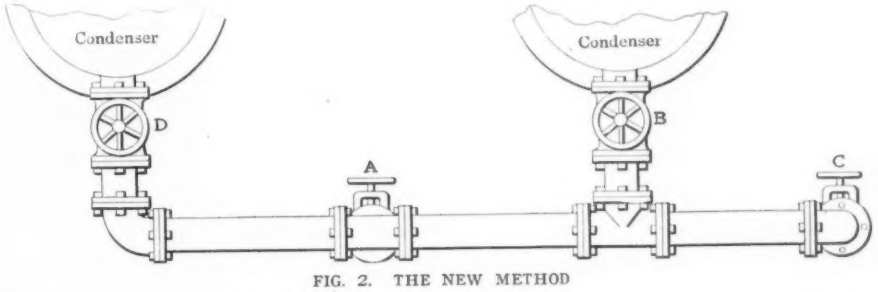


FIG. 2. THE NEW METHOD

Underground Insulation of Steam and Hot Water Pipes

In one plant I had charge of we laid 8-inch common vitrified drain pipe, being careful to have all joints flush and even, so there would be no obstruction on the inside of the pipe. All joints were made tight with portland cement mixed half and half. I used heavy brass pipe from basement to basement, having a union at each end of the conduit, so that if a leak should occur the pipe could be easily disconnected at both ends, pulled out into the basement and disconnected without much trouble or expense.

By being careful in making joints we succeeded in getting everything tight and it stood the test for six years without a leak. Brass pipe is expensive, but it will pay in the end, if properly installed. We also ran our power and electric-light wires in a similar conduit and never had any trouble through grounds or short-circuits.

W. E. SARGENT.

Franklin, Mass.

Exhaustion of Ignition Batteries

R. Manly Orr's query in one of the recent numbers, under the above heading, might form the text for a good deal of theorizing, since ignition batteries are a rather uncertain proposition and form a subject that seems to be but little understood by the average person. Mr. Orr, however, does not state what type of battery he has in mind, whether of the wet, dry, or storage variety.

If he refers to a wet battery, of the Edison-Lalande type, employing a caustic-soda solution as an electrolyte, and zinc and cupric oxide as the elements, he would probably find the life of his battery somewhat prolonged by doubling the speed of the engine, and thus cutting down the time element in the contact.

It could not be expected, however, that the life would be increased in direct proportion to the time element of contact, for the reason that the intermission between discharges is so exceedingly short as to give the battery practically no chance to recuperate to any appreciable extent after discharge. Furthermore, the internal resistance of a battery of this type is very low, permitting of more or less internal action when the battery is on open circuit. In consequence of this the age of the charge in the battery cuts quite a figure.

A battery of this kind generally has a very low voltage, varying from five-eighths to seven-eighths of a volt, and high initial amperage, making it possible for the battery to stand heavy discharges for short periods, with consequent long life on light-discharge service. This type of battery is built in capacities of from 150 to 600 ampere-hours, and is admirably adapted to gas-engine ignition service.

There are, however, three objections to this form of battery: their first cost, cost of renewals and low voltage; the last feature making it necessary to employ a larger number of cells in series to get the necessary six or eight volts generally used in ignition work. Under normal conditions, with no accidental short-circuits, a battery of this kind should give from 10 to 15 per cent. longer service at double the speed of contact.

With the use of dry batteries we are confronted with a different proposition. Practically all American-made dry cells use carbon and zinc as the elements, and ammonium chloride as the electrolyte. This combination results in a dry cell having an electromotive force of approximately 1½ volts, with a high internal resistance. Due, however, to the comparatively high voltage of the cell, and the close association of the active elements in the cell, there is a constant tendency toward internal action on open circuit, which would operate to shorten the life of the battery. In consequence of this, most manufacturers of standard dry cells endeavor to keep the internal resistance of the battery moderately high, and have adopted the practice of dating all their cells, claiming that they should be placed in service within sixty days of date of manufacture, to insure average life.

The idea is pretty general among combustion-engine users that a dry cell in order to be good must have a high initial amperage, and some refuse to accept a cell unless it tests 22, 25 or even up to 30 amperes on short-circuit through an ammeter.

This is all wrong. The initial amperage is merely an indication of the internal resistance of the battery, and has nothing whatever to do with the life of service. A battery showing a high initial amperage is most likely to have a filler of some inert substance having a low electrical resistance, but which serves no useful purpose in the battery. This would make the battery very short-lived, and the service would be exceedingly poor. It is to be noted that quite frequently, when a battery shows an initial amperage of from 22 to 30, if left on short-circuit for a few minutes through an ammeter, the amperage will drop rapidly, going as low in some cases as 10 or 12.

On the other hand, a good standard cell in prime condition, showing an initial amperage of 14 to 20 on short-circuit, will drop back a half ampere or so and remain there indefinitely.

It would hardly be practicable or economical to run a gas engine on dry battery for a period of six months, and get any sort of service out of it. The ideal battery for ignition service is, of course, the storage battery. This form of battery, having an electromotive force of approximately 2 volts per cell, gives an output that is absolutely constant, and under easy control. The first cost is practically the only cost, as the expense for recharging is comparatively light.

A. P. H. Saul.

Buffalo, N. Y.

Testing Tanks for Steam Turbines

We recently had a test on one of our turbines to determine the steam consumption per kilowatt-hour. Fig. 1 is a cross-section through one of two 4x4-foot

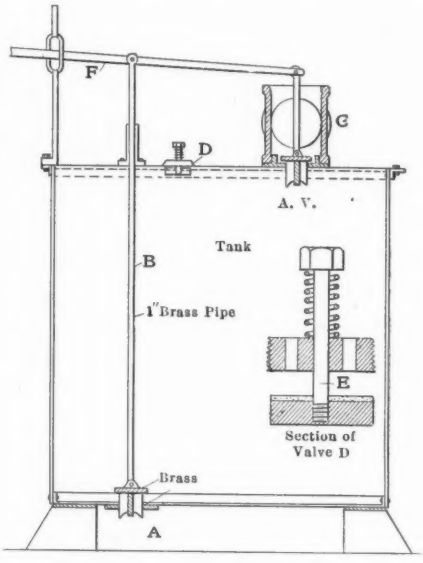


FIG. 1

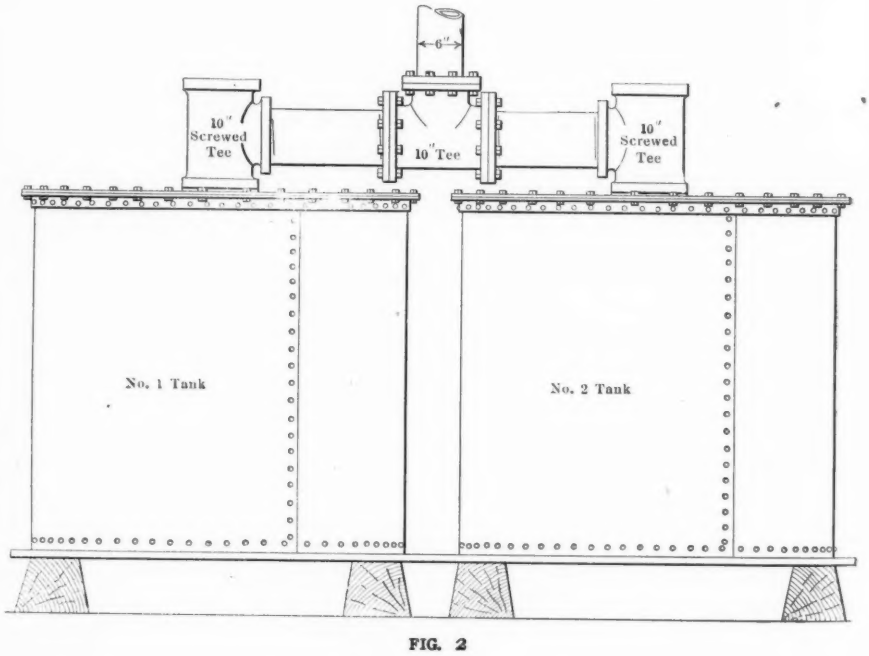


FIG. 2

tanks which were leveled up and filled with water, the water being carefully weighed in 400-pound lots. The tanks each contain practically 3110 pounds of water.

It will be seen from Fig. 1 that only one valve can be opened at a time, each valve stem being the fulcrum, by means of which the other valve is lifted from its seat. The valves are 6 inches in diame-

ter, are made of brass and fitted with a leather washer between the seat and disk. The lower valve seat *A* is a brass ring, 1 inch thick, riveted to the bottom of the tank. The valve stems are made of 1-inch pipe. The stem *B* passes up through a 1¼-inch brass pipe which acts as a guide. The discharge valve is shown open, and its construction is readily seen.

The admission valve cannot be opened until the discharge valve is closed, and *vice versa*. The upper, or admission, valve seat has a projecting ring above it, which is threaded with a standard 10-inch pipe thread to which the tee *C* is screwed, its function being shown in Fig. 2, which also shows the connection between the tanks.

The object of the snifting valve *D* is to admit air to the tank when discharging, and also to let the air escape from the tank when filling by simply pressing the hand on the valve stem. The valve opens inwardly and is ordinarily held shut by a spring. An enlarged view of the valve is shown at *E*, Fig. 1. The threaded portion is made of a 2-inch pipe, and the disk has a leather face. The operating lever *F* is provided with a stop, the object being to prevent lifting the valves too far from their seats.

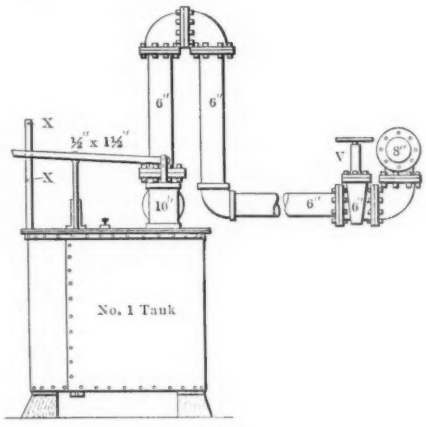


FIG. 3

In Fig. 2 each tank is shown connected to a short 10-inch nipple screwed into the tee. A flange on the end of each nipple is bolted to a tee, having the outlet facing upward. The 6-inch pipe represents the turbine wet-pump discharge.

In Fig. 3 is a side view of the tank and the connections to the discharge of the wet pump. The 8-inch pipe shown is a common discharge from two turbines, and runs about 20 feet higher than the horizontal pipe. It discharges directly into the heaters. The discharge from the wet-vacuum pump being intermittent, we shut the valves on the heaters and all the water passes through the 6-inch pipe to the tanks. By about half closing the 6-inch valve *V* the pipe to the heaters is made a sort of air chamber on the discharge pipe from the wet pumps, and a steady flow of water is the result.

The "gooseneck" shown is to prevent air finding its way back to the wet pumps over the top of the water in the discharge pipe.

While conducting the test a man was stationed at each operating lever to fill the tank, while the other is being discharged. We set the 6-inch valve about half open, and shut off the valve on this line above the heaters. Then we let the water flow until the vertical pipe to the heaters was normal, when at a predetermined signal one admission valve was opened. When the man on tank No. 1 closes the admission valve preparatory to opening the discharge valve, the man on tank No. 2 must be ready to open his admission valve. This is, of course, an easy matter, for while it takes 1¾ minutes to fill a tank, the same tank can be emptied in 1 minute 20 seconds.

In closing a test we get one tank full and when the water overflows at the tees, as it did in the start, the last reading on the wattmeter is taken.

E. H. LANE.

Kansas City, Mo.

Valve Problem Solution

Herewith is a solution to George P. Pearce's valve problem, as published in the December 8 issue, page 970. As seen by his illustration, the pressure on top of the valve equals the area of a 5-inch circle multiplied by 100 pounds per square inch equals 1963.5 pounds. The total pressure downward equals

$$1963.5 + 5 = 1968.5 \ lb.$$

The area of passage of seven 1-inch holes is

$$7 \times 0.7854 = 5.4978 \ sq.in.$$

and

$$1968.5 \div 5.4978 = 358 \ lb.$$

pressure per square inch required to raise the valve.

As soon as the pressure exceeds 358 pounds per square inch the valve raises and a much larger area than that presented by the seven 1-inch circles is exposed.

G. A. GLICK.

Madison, Wis.

The pressure is 100 pounds per square inch on top of the valve. Neglecting friction, 100 pounds per square inch on the under side of the valve will balance 100 pounds per square inch above the valve; therefore, the extra pressure is that required to lift the weight of the 5-pound valve.

It makes no difference whether the valve is 5 or 50 inches in diameter, as we are dealing with pounds pressure per square inch and the weight of the water only affects the area of the valve covering the holes in the seat. The area of the holes is 5.4978 square inches, and the total pressure to be overcome or equaled is

$$100 \times 5.4978 + 5 = 554.78 \ lb.$$

The total pressure per square inch required to lift the valve would be

$$554.78 \div 5.4978 = 100.9 \ lb.$$

per square inch. This would be increased slightly on account of friction of the valve on the stem and also the water in the holes in the valve seat.

J. C. HAWKINS.

Elyria, O.

The receiving pressure will act on the whole area of the valve or 19.635 square inches, and this times 100, the pressure, equals 1963.5 pounds pressure on the valve. The valve itself weighs 5 pounds, so the total pressure acting on the receiving side will be 1968.5 pounds.

It will take this much pressure on the delivery side just to raise it, but the area that this pressure has to act on is only the area of the seven holes or

$$7 \times 0.7854 = 5.4978 \ sq.in.$$

The total pressure necessary to raise the valve will be 1968.5 and the pressure per square inch will be

$$1968.5 \div 5.4978 = 358 \ lb.$$

BERT A. SNOW.

Ithaca, N. Y.

Firing Stationary Boilers

In a recent article, "Firing Stationary Boilers," by F. R. Wadleigh, there is one point which I do not understand. He says: "The fireman should know that the place to regulate or shut off draft is by the stack damper and not by the ashpit doors. The latter are for the purpose of regulating the air supply."

I cannot see why the air supply cannot be regulated entirely by the stack damper, provided its design and the character of the coal will permit. A smoky coal will clog the tubes with soot a great deal more quickly with the damper partly closed than with the ashpit doors closed. It took me a long time to figure out why a certain amount of gases passing through the tubes in a certain time would not have the same velocity under both conditions. I finally decided that with the ashpit doors closed the gases were lighter, due to reduction of pressure and, therefore, had a higher velocity and carried off more of the particles of soot. So far as the simple admission of a certain amount of air to the fire is concerned, I cannot see what difference it makes whether it is regulated at the damper or the doors.

There are two good reasons why the ashpit doors should be kept open: With the doors closed there is more leakage of air above the grates through the setting, while with the ashpit open there is more radiation of heat which lowers the temperature of the ashpit and helps to preserve the grates.

J. F. BRADLEY.

Valparaiso, Ind.

How Compression Saves Coal

The article under the above caption, by M. E. Copley, does not tell why nor how he came to his conclusion. He presents a set of diagrams which I have taken a little time to analyze. The low-pressure diagram shows practically no compression, but does show a great deal of back pressure, due to the fact that there is no compression. If he would overcome the back pressure, he must make his release earlier, which means that the exhaust valve must open and close earlier in the stroke, which will give compression, something Mr. Copley does not want.

The average mean effective pressure of both ends is, say, 0.835 pound, while the average mean effective pressure would have been, say, 0.895 pound, had the valve opened earlier and the area represented by the back pressure been saved, making a saving or additional power of 0.06 pound mean effective pressure. This is worse than lost becaust it represents negative power, or power pushing against the piston tending to stop it, especially at a time when it is most needed, at the beginning of the stroke. If there is a loss of 0.06 pound mean effective pressure through loss of area in the diagram, and that amount is pushing in the wrong direction, the total loss is $0.06 \times 2 = 0.12$ pound mean effective pressure. It is true that some area would be lost through compression, but not as much as the negative pressure would cause.

It is a difficult matter to figure out how a saving is made by cutting out compression and cutting in back pressure.

Another bad feature shown by the diagrams is the great difference in the load between the high- and low-pressure sides. As the size or speed of the engine is not given, I am assuming that the ratio between the cylinders is 4 to 1. The average mean effective pressure of the high-pressure diagrams is, say, 58.29 pounds, while the average mean effective pressure of the low-pressure diagrams is 0.835 pound. Therefore, the total horsepower of the engine would be

$$58.29 + 0.835 = 59.125.$$

Now, if that work were equally divided between the two engines the mean effective pressure of the low-pressure side would be

$$59.125 \div 4 = 14.78$$

pounds, but as the actual mean effective pressure is only 0.835 pound, the low-pressure cylinder is only doing

$$14.78 \div 0.835 = 17.78,$$

or 1/17.78 part of the load. In other words, the high-pressure side is doing nearly 18 horsepower, while the low-pressure side is doing only 1 horsepower. There may be some special reason for distributing the load this way, but if not, it will be a surprise to see what a difference it will make in the coal pile by raising the receiver pressure to 18 or 20 pounds, cutting in a little compression and cutting down the back pressure.

TOTT JENKINS.

De Kalb, Ill.

Connecting Rod Design

In regard to the article on "Connecting Rod Design," in a recent issue, I wish to criticize the crank end of Mr. Willard's rod, which is herewith reproduced in Fig. 1. In the first place it is stated that as flanged brasses are used, it is necessary to have a removable end. A better design is to have the top of the rod open as shown in Fig. 2, the brasses being clamped by a lipped cover plate. In Fig. 1 the end bolt *D* is evidently subjected to the entire stress on the rod on the inward stroke of the engine, while Fig. 2 presents a solid thickness of metal at the bottom and a lipped cap at the top to resist this stress.

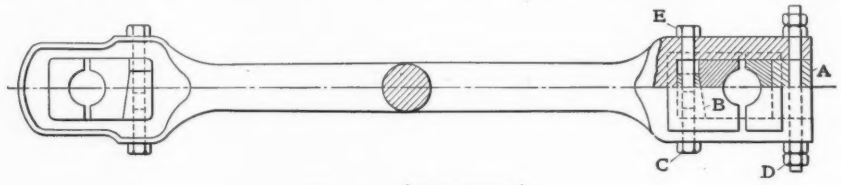


FIG. 1. (REPRODUCED)

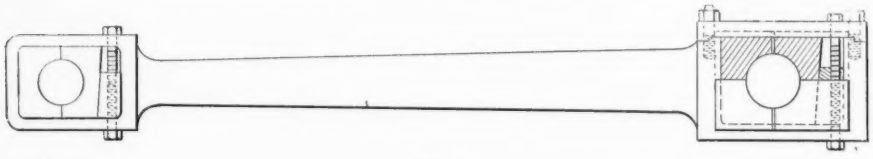


FIG. 2

It should also be noted that in Fig. 2 the adjusting wedge is outside of the the pin, while at the crosshead end it is inside, this end being practically identical to Mr. Willard's form. Such an arrangement of the means of adjustment is very necessary in order to keep the rod of the proper length, and the clearance in the cylinder equal.

In regard to cost of manufacture, it will be seen that the rod in Fig. 1 must have both ends machined on a slotter, while the crank end of the rod in Fig. 2 may be finished in any size on a planer with a corresponding reduction of time. I also differ with Mr. Willard in regard to the adaptability of such a rod to marine engines, though it is the very best type for horizontal engines, air compressors and locomotives.

H. L. DEAN.

Hyde Park, Mass.

Method of Calculating Capacity of Absorption Machinery

A very convenient method of calculating the capacity, in tons of refrigeration, of an absorption machine, is as follows: Take the revolutions per minute, or total revolutions, with a counter, of the aqua pump during the time desired for determining the load of the machine; also take the Baumé and temperature of weak and strong aqua at frequent intervals during this time. Note the back pressure on the expansion coils, also.

Determine the capacity of the aqua pump in cubic feet per revolution, taking into consideration the aqua piston rod. Correct from the table the actual Baumé readings of strong and weak aqua for temperature, i.e., reduce both readings to 60 degrees Fahrenheit. From the tables, get the per cent. of ammonia in strong and weak aqua, also the specific gravity of strong aqua, using the corrected Baumé readings.

The weight of a cubic foot of water, 62.5 pounds, times the specific gravity of strong aqua equals the weight of a cubic foot of strong aqua. The revolutions per minute of a pump times the cubic feet per revolution times the weight of a cubic foot of strong aqua equals the pounds of strong aqua pumped per minute, or *M*.

The tons of refrigeration per day of 24 hours equals

$$\frac{M\,(x-y)}{100-y} \times \frac{r}{284{,}000} \times 1440,$$

where

x = Per cent. of ammonia in strong aqua,

y = Per cent. of ammonia in weak aqua,

r = From ammonia tube, equals the value in B.t.u. of one pound of anhydrous ammonia at the back pressure of the expansion coils, allowing for the temperature of the anhydrous ammonia at the expansion valve, and the temperature corresponding to the back pressure.

This method is by no means absolutely accurate, due to slippage in the aqua pump, inaccuracy of gages, etc., but it serves as a handy check on a machine or for daily comparison.

G. A. ROBERTSON.

St. Louis, Mo.

Firing Boilers

In the December 8 number, page 955, F. R. Wadleigh has an instructive article on firing boilers. On page 959 he says, regarding the wetting of coal, "the practical reasons for wetting coal will generally outweigh the theoretical or chemical reasons for not wetting it."

Wet coal will coke better, make a hotter fire and less smoke than dry coal. At one time I held the same opinion as Mr. Wadleigh, but in looking over my table of boiler tests I saw that coal wet so as to make a good fire evaporated about 8 per cent. less water than ordinary dry coal, and I gave up wetting it. The water must be evaporated, and during the evaporation the fire is not hot enough to decompose it.

W. E. CRANE.

Broadalbin, N. Y.

Hard or Soft Condenser Tubes

On the editorial page of the December 8 issue the attention of the reader is directed to the use of hard or soft condenser tubes. Hard tubes are liable to crack, although the process of manufacture may prevent most of it. Cracked tubes are liable to occur, not only condenser tubes, but brass or alloyed pipe of all kinds, even though no work is put upon them. When a pipe is drawn through the die it becomes hard, and to be worked further it must be heated to a low red, which anneals it.

While the tube is in a hard condition a severe strain is placed upon every fiber, and if put into the annealing oven just as it comes from the die it would probably crack. To prevent this cracking, a man lifts the tube above his head and throws it violently to the floor in such manner as to bend it slightly.

When finishing a tube for power purposes it should be left semi-annealed; if not, even the best made tubing may crack in use. With pure copper tubes there is not as much trouble, but they are expensive. Brass tubes are made of different metals with different densities and expansions, and a tube left hard appears to be full of strains which mean its destruction.

With salt water, even pure copper is not free from corrosion, and it could hardly be expected that its alloys would be. It is possible that hard tubes may have incipient cracks which hasten corrosion, and that absence of these cracks may mean longer life to the semi-annealed tube.

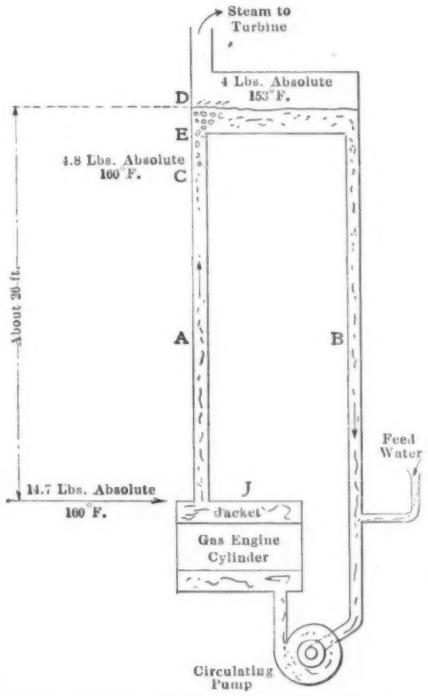
Nickel tubes were tried, and for a time it seemed as though the right thing had been found. They could be more heavily annealed than brass tubes and still be stiff enough to work, but they were not proof against corrosion.

W. E. CRANE.

Broadalbin, N. Y.

Composite Power Generation

Recently, in an editorial on "Composite Power Generation Again," it is stated that the writer does not understand how the heat in 40 pounds of jacket water can be concentrated to evaporate 3 pounds. The accompanying sketch shows an arrangement for doing this. The water in the cylinder jacket *J* will be discharged at, say, 160 degrees Fahrenheit, and at a pressure of 14.7 pounds absolute. As the water rises in the pipe *A*, the pressure, due to gravity head, diminishes until at some point *C* the pressure will exactly correspond to the pressure of saturated steam at 160 degrees Fahrenheit. Above this point, if no steam were formed at some point *E* the water would be at 44 pounds absolute pressure, and a temperature of 160 degrees Fahrenheit; but this



ARRANGEMENT FOR CONCENTRATING JACKET WATER HEAT

is just as impossible a condition as water at 250 degrees Fahrenheit at atmospheric pressure. Under such conditions part of the water will be evaporated at the expense of the heat in the remainder, so that when the water has risen to point *D*, its temperature will have been reduced to 153 degrees Fahrenheit and it will have given off a quantity of steam.

The water at this temperature being returned to the jacket through pipe *B*, by the circulating pump, will again be heated to 160 degrees Fahrenheit and the cycle repeated. Instead of circulating 40 pounds of water per brake horsepower per hour, it would be necessary to circulate 3500 B.t.u. divided by 7 degrees temperature change, which would equal 500 pounds per brake horsepower-hour. This would, of course, require liberal-sized pipes, but a short calculation will show that 5-inch pipes would be large enough for a 500-horsepower gas engine.

I am not able to follow exactly the reasoning in the last paragraph of the number of pounds of water that could be evaporated by the exhaust gases. Using the figures given, 4000 B.t.u. per horsepower, 87 per cent. of this would be 3500 B.t.u. According to the tables of steam in Kent's handbook, the total heat of steam at 150 pounds gage pressure is 1193. Subtracting from this the temperature of the feed water, 200 degrees, as given, leaves 993 B.t.u. required per pound of steam; 3500 B.t.u. divided by 993 equals 3½ pounds per horsepower-hour, instead of 1½ pounds. Which is the nearer right?

There is one feature which may make up to some extent for the small output which it is said would seem scarcely worth the complication necessary for its production. The heat produced by the exhaust can be stored in strong hot-water reservoirs during seasons of normal load and utilized on the peak load. This would supply overload capacity, in which the gas engine has always been sadly lacking.

A. T. KASLEY.

Swissvale, Penn.

Faulty Indicator Diagrams

In a recent number, J. Zeelenberg shows diagrams taken from a high-speed engine and asks for opinions as to the trouble and for a remedy. As he says, the diagrams show a very one-sided adjustment, the crank end doing practically no work, and I suspect the coal pile suffers because of it. The head-end diagram shows that the exhaust valve closes so early the compression is excessive. On the same end the steam port closes late, giving a release pressure of apparently 20 pounds. The crank-end steam port barely opens at all, and the small amount of steam which does get through expands down to atmospheric pressure, when the valve is reversed and compression begins.

My remedy would be to lengthen the valve stem for a more equal steam distribution. I think it will be found that the eccentric requires moving ahead in the turning direction, until a nearly vertical admission line is obtained.

In the same number, M. E. Copley shows a set of diagrams from a compound engine which, he says, is the adjustment he finds best for that particular engine, and I have no doubt it is. At the same time, to an outsider, 4½ to 5 pounds receiver pressure looks low, with a boiler pressure of 150 pounds. Another thing, are not his low-pressure exhaust valves slow to open, preventing the condenser from getting in its work, until the piston has moved back a very noticeable portion of its stroke? There is certainly a

very small amount of compression, but is it not at the expense of the condenser?

WILLIAM AULD.

Milwaukee, Wis.

A New Method of Firing

I do not approve of a thick bed of coal on the front end of grates with little or no depth of fire on the back end near the bridgewall. The proper method of coking is to keep a good, thick fire on the back of the grates at all times, as well as on the front. In this way, after being pushed back and replaced by a new charge, the fire will be of equal depth all over the furnace. None but an ignorant or lazy fireman would keep coal piled up just inside the furnace door.

One of the first things a fireman should learn is to keep a good thick fire in the back end of the furnace; otherwise, the cold air, meeting little or no resistance, will rush through the thin layer of coal without becoming heated enough to mix with the gases from the front. The bridgewall, instead of being heated hot enough to assist combustion, will retard it by cooling the gases passing over it.

C. E. BASCOM.

Marlboro, Vt.

Criticism of Turbine Installation

The recent article describing a mammoth turbine for Buenos Aires strikes me as a good one on which to base a discussion. First, I would like to call attention to the amount of water the circulating pumps are capable of delivering per hour. Each pump, it is stated, will pump 112 gallons per second; the two pumps will, therefore, pump 224 gallons per second, providing they are both in condition to run at the same time. This is 13,440 gallons per minute, or 806,400 gallons per hour, and assuming 8.3 pounds per gallon (critics, excuse the figure) this will amount in round numbers to 6,693,120 pounds per hour. The turbine at maximum load develops 14,200 horsepower, which is equivalent to 10,593 kilowatts. It is stated that the machine will develop a kilowatt-hour on 13.86 pounds of steam. This will mean about 147,000 pounds of steam, round numbers, to be condensed per hour. Dividing 6,900,000 by 147,000, we get as the circulating water per pound of steam 47 pounds, nearly.

This is the first point I would like to see discussed. The American practice is to allow not less than 60 pounds of condensing water per pound of steam. I think that a larger circulating-pump capacity should have been provided. The temperature of the water the year round must be taken into consideration, the final temperature of the circulating water, and, last but not least, the temperature of the condensed steam. This last point is one I am very much interested in. At what temperature can the condensed steam be maintained with a 28½-inch vacuum?

The second feature in the plant in question is the cooling surface in the condenser. It is 14,000 square feet, and at maximum load of the turbine the ratio is 1 square foot of cooling surface per horsepower. The latest American practice is to have 2 square feet per horsepower for reciprocating engines and 4 square feet per kilowatt for turbines. This may seem to be a rather liberal allowance, yet I have found in my own experience that it is none too much, for several reasons. Trash may stop up a number of tubes between morning and shutting-down time, and it is not always possible to shut down the condenser and clean them out. In summer the circulating-water temperature may get rather warm, or the circulating-pump capacity may decrease. In the case of a turbine, in order to keep the steam consumption down to 13.86 pounds per horsepower per hour, it is necessary to have about 28½ inches of vacuum, and in order to do this there must be sufficient cooling surface. It has been my actual experience that no matter how much water in put through a tube, the element of time has considerable to do with the amount of heat it can absorb. From the foregoing it would seem that there is not enough cooling surface to this particular condenser.

I also notice that this station is making a bid to be classed among the most economical of power stations, by using electric auxiliaries. I fail to see where these so-called modern improvements are making any more than an apparent saving. Suppose the prime mover has a thermal efficiency of 18 per cent. and the electrical end of the auxiliary has a 90 per cent. efficiency, the combined efficiency is 16.2 per cent. This same plant, if served completely by electric auxiliaries, will probably have a feed-water temperature of 100 degrees Fahrenheit, a loss of 11 per cent. in fuel. How much do they gain by the modern auxiliaries? This latter question applies to a good many modern power stations, in part if not altogether.

E. H. LANE.

Kansas City, Mo.

Repairing a Broken Eccentric Rod

Owing to the heating of the steam eccentric, the eccentric rod of a 14 and 26 by 30-inch high-speed Corliss engine broke in three pieces. The first break happened at the rocker-arm brass, where the diameter was less than ¾ of an inch. Coming in violent contact with the concrete floor, it again gave way near the eccentric strap. The oil guard was demolished and a portion of the automatic oiling system was dismantled. It was imperative to have a new rod in place before 4 p.m. the next day, but to get a rod from the maker inside of 18 hours was impossible. It was a case of hustle, therefore, to make a new rod in time for the evening load. Fig. 1 shows the valve gear; at *A* is shown the position of the steam-valve cranks. There is no valve-stem stuffing box, as a ground joint of a special oval pattern makes it unnecessary, as shown.

On this engine the opening in the steam bracket was so small that half a turn of

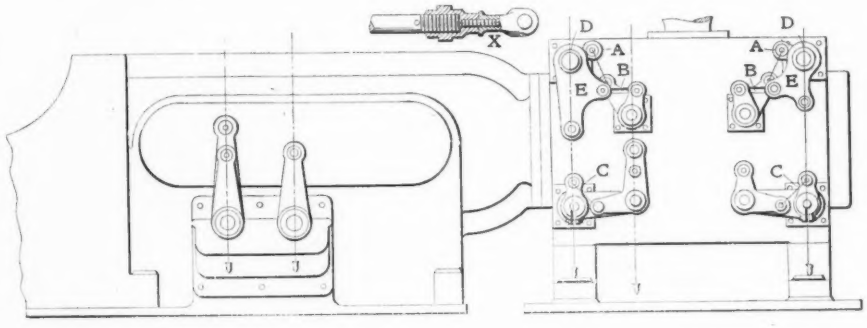


FIG. 1

the eccentric rod one way or the other would cause the valve crank to knock against the edges. Hence, the new eccentric rod had to be the exact length, or we were liable to have another accident in the shape of a broken valve bracket.

With the eccentric rod removed, the striking points of the valve cranks were marked on the box of the rocker arm. The links *B* were then removed and the eccentric rod screwed in for as near its right length as we could determine. The air pump was started and the engine allowed to be turned slowly by the vacuum. The length of the eccentric rod was so adjusted that the mark on the rocker arm traveled slightly inside the marks on the box cover. The links *B* were replaced, the engine brought to speed and load given it, when the job was completed with the aid of the indicator. Some may wonder why the reach rod was not taken out instead of the links *B*. There is only one position of the crank which permits the reach rod on this engine to be taken out, and that position is difficult to stop at. At *X* is shown how the narrow end of the eccentric rod was stiffened and strengthened, by a special nut planned by the superintendent.

At first sight the valve gear looks to be quite complicated, and many would infer that it is difficult to adjust. An inspection of the plumb lines in Fig. 1 shows that the valves are almost as easy to adjust as slide valves. No adjustment is possible on the brass links *B* of the steam valves and *C* of the exhaust valves. After adjusting all rods to their proper length, place the engine on the crank-end center, turning the engine in the direction it is desired to run. Then loosen the hub bolts and set screws of the flywheel and revolve the latter on the shaft, until the required lead is obtained at the crank end. On this particular engine the lead is ⅛ inch on the high-pressure side, and 3/16 inch on the low-pressure cylinder. Tighten the hub bolts and set screws on the flywheel, and place the engine on the head-end dead center. The lead on the head-end valve should be practically the same. If it is not, equalize it by means of the steam rod. On the steam-valve bracket washer *D*, Fig. 1, will be found five marks, the two outer corresponding with the maximum travel of the steam rockers *E*, the two next with the minimum travel, and the middle mark with the central position. These marks should be verified before the steam bonnets are replaced. The maximum-travel marks are easily found by rotating the engine.

To find the minimum-travel marks, loosen the tension on the governor springs *A*, Fig. 2, being careful to count the number of revolutions the springs are turned, and tie the weights *W* snugly against the stops *B*. Each steam valve should now travel an amount equal to its lap only, i.e., the two marks (the valves are ported) on the circular end of each valve should come line and line with the marks on the valve chamber. This insures that the engine will not run away, should the load be suddenly thrown off. Do not, however, let the valves travel an amount less than their lap, for the governor springs are liable to be overstretched and strained.

When the valve and valve-chamber marks on either side coincide, the mark on each of the rocker arms *E* will be line and line with one of the minimum-travel marks on each of the two washers, if these marks are correct.

The exhaust valves, when the rocker arms are central, as in Fig. 1, have 3/16-inch lap on the high-pressure side, and ¼-inch on the low-pressure side. Compression begins when the crosshead is within 3⅗ inches, or 12 per cent., of the end of its stroke. For the benefit of those who might wish to study the action of the governor, the layout is plotted by the dotted lines in Fig. 2.

Next place the flywheel in such position that the nuts on hub bolts are downward; loosen and remove them one by one, heat the bolts to a cherry red and immediately replace them. Tighten the nuts with a hand wrench only, and do not use a hammer or pipe to set them up, as contraction due to cooling will amply take care of that.

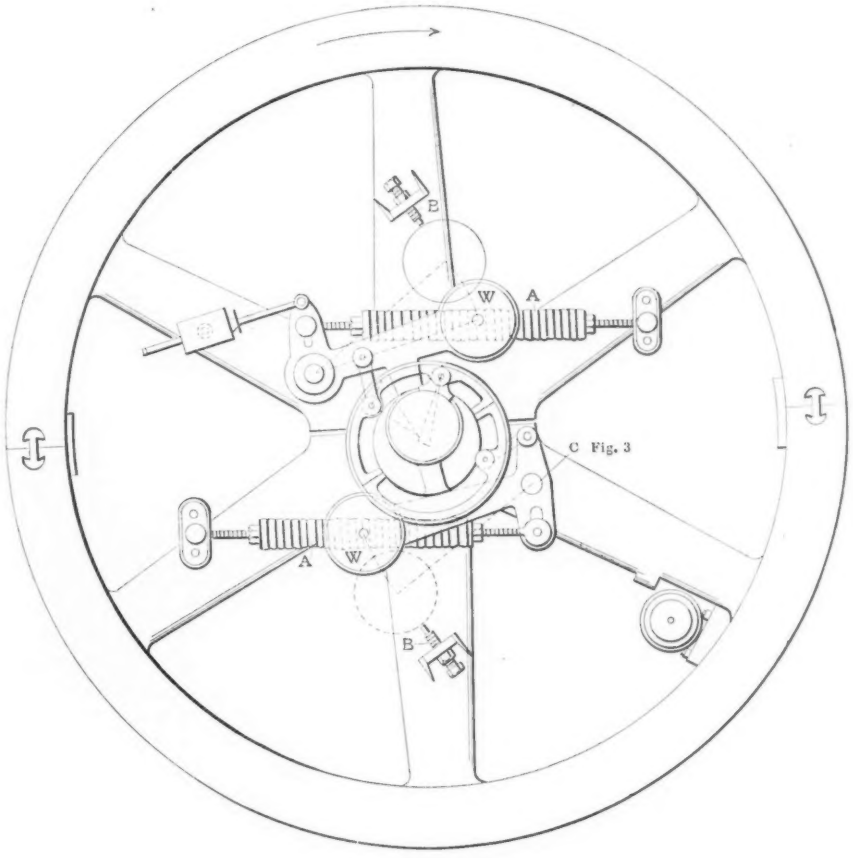


FIG. 2

Fig. 3 shows the low-pressure eccentric and the method of changing the receiver pressure. Lengthening the link rod *A* shortens the cutoff, and consequently raises the receiver pressure. The spring *B* is connected to the governor weight arm at one end and at the other to the worm gear which is operated by the small motor shown, which is used to make slight changes of speed while synchronizing from the switchboard.

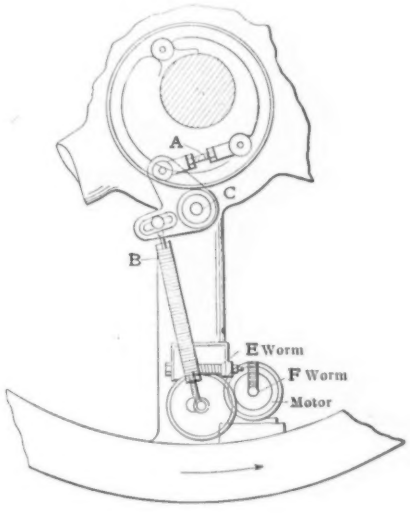


FIG. 3

R. O. RICHARDS.

Framingham, Mass.

Hygrometry

In J. H. Hart's contribution on "Hygrometry," which appeared in a recent number, in the middle of the second column he states: "If immediately in contact, it in general becomes *saturated* for that temperature, in precisely the manner that *steam becomes saturated in a boiler* and remains so."

I should like to draw attention to the words in italics. In my opinion, when considering "steam" the word "saturation" applies to heat; that is to say, when we state that steam is saturated we intend to convey the idea that it is saturated with heat units. Such being the case, it is evidently impossible theoretically for the steam to contain any moisture at all, as any further addition of heat merely becomes superheated.

Practically, we allow for a certain percentage of moisture being present in saturated steam, and to satisfy this question we introduce the term "dry," or "commercially dry saturated steam," which contains about 2 per cent., by weight, of moisture.

W. VINCENT TREEBY.

West Hartlepool, England.

Polish for Brass Steam Pipes

Herewith is a recipe for a polish for brass steam pipes, or other hot-brass work in the engine room, which I have used for years and believe to be the best polish that can be made:

Melt together 1¼ pounds of cake tallow, 2 ounces of spermaceti, 2 ounces of gum camphor and 2½ ounces of beeswax. Then add 8 ounces of raw linseed oil, 10 ounces of coal oil and 2 pounds of tripoli powder.

J. B. Draper.

Kenton, O.

Pump Suction Limit

In a recent issue a correspondent asks why a pump will not lift water a distance nearly equal to the head balancing the atmospheric pressure, say 32 or 33 feet. Leaving out the question of water temperature, for the time being, and assuming that the suction pipe is air-tight, then

A_p = *Total suction limit* =

$$H = \frac{v^2}{2g} + F_p,$$

where

A_p = Atmospheric pressure expressed in feet,

H = Elevation of pump above water level,

v = Velocity of flow in feet in suction pipe,

g = Gravity equals 32.16,

$\frac{v^2}{2g}$ = Velocity head,

F_p = Friction loss in feet, which depends upon the velocity of the water in the suction pipe. This friction factor includes losses in foot valve and elbows.

From this it is seen that the hight to which a pump will lift water by suction can never equal 32 or 33 feet, unless the flow in the suction pipe is extremely slow.

If the temperature of the water is taken into consideration, it still further lowers the lift, as will be seen from an examination of the following table, based on atmospheric pressure at sea level:

Temperature of Water. Deg. Fahr.	Pressure of Vapor in lb. Per Sq. Inch.	Limit of Suction Head, Considering Temperature Only.
70	0.36	32.96 feet.
80	0.50	32.6
90	0.69	32.2
100	0.94	31.4
110	1.26	30.9
120	1.68	29.7
130	2.22	27.3
140	2.87	25.9
150	3.70	24.8
160	4.72	22.5
170	5.98	19.6
180	7.50	16.9
190	9.33	9.9
200	11.52	9.3
210	14.12	1.1

In the foregoing it was assumed that the suction pipe was perfectly air-tight, but as this is hard to secure, due allowance should be made.

John B. Sperry.

Aurora, Ill.

A Homemade Socket Wrench

On taking a turbine pump apart one day, to remove a worn-out impeller, it was found necessary to remove five 1-inch hexagon nuts from the position shown in Fig. 1. A hole in the outside wall was

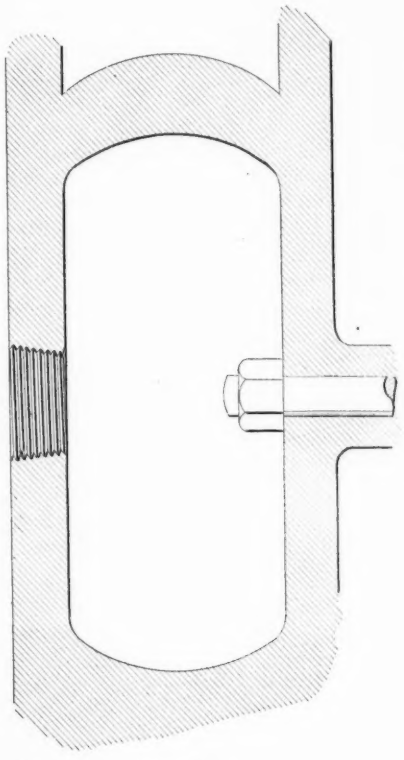


FIG. 1

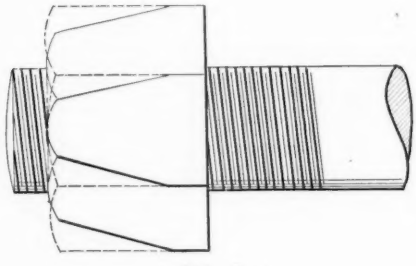


FIG. 2

closed by a 2-inch plug, and to reach the nuts a socket wrench was required, and none of suitable size being at hand, it was decided to make one.

Picking out a 1-inch bolt and nut from the scrap pile I dressed the nut down to a taper, as shown in Fig. 2, when it was found to just about enter a piece of 1½-inch gas pipe. To heat the end of the pipe and forge it into a hexagon shape to fit the nut was then a simple matter, and it proved an excellent wrench.

In the same manner a 1¼-inch pipe may be made to fit a ¾-inch nut, and 1-inch pipe will answer for a ⅝-inch nut. Socket wrenches of these sizes will always be found handy around a steam plant.

R. Cederblom.

Gary, Ind.

Storage Battery Troubles

In a recent number, J. M. Herwig narrated his troubles with a storage battery which apparently became dead shortly after being charged. The battery has evidently had hard usage, and he will doubtless find that the cells have either short-circuited or accumulated sulphate. Short-circuiting may be caused by sediment accumulating in the bottom of the cell until it reaches the plates. The cells should be cleaned frequently and new electrolyte added to replace that which is lost, to bring the gravity of the solution up to 1.210. If there is any suspicion that there is foreign matter in the solution, new electrolyte should be used.

Care should be taken while cleaning the battery not to allow the negative plates to dry in the least. If they are allowed to dry it will be necessary to charge them again for a period equal to the initial charge.

Sulphating is the most troublesome element to contend with in a storage battery. It is formed when a cell is nearly discharged and is noticeable by the formation of a white coating over the plates. If a cell is discharged and allowed to stand with the electrolyte in place it will sulphate very rapidly. This also causes buckling of the plates, because the formation of sulphate in the active material causes it to expand, forcing the grids out of shape. This sulphate, being a non-conductor, increases the resistance of the plate, and when it is removed carries part of the active material with it. Long-continued charging at a moderate rate will gradually remove all sulphate from the plates.

When the cells are fully charged and in good condition the positive plates should be of a brown or deep red color and the negative plates gray. The battery should never be charged above its maximum charging rate, because it will cause a rapid accumulation of sediment, excessive evaporation of the electrolyte and the life of the battery will be much shortened. A low-reading voltmeter should be used for testing each cell, and a discharge lower than 1.8 volts per cell should not be allowed. The battery should be charged until the voltage shows 2.5, then the charge should be cut to about half and continued until the cells again show 2.5 volts; the battery is then fully charged. As the age of the battery increases the final charging voltage will drop to about 2.4.

The change of temperature affects the final voltage so that it is lowered with an increase of temperature above 70 degrees Fahrenheit and correspondingly increased by a lowering temperature. After the charge is completed and the current is cut off the voltage will drop to about 2.2 volts per cell, and when the discharge is started it will drop to 2 volts.

The temperature of the surrounding air of a storage battery should rise no higher than 80 degrees Fahrenheit and drop no lower than 50 degrees Fahrenheit. If the surrounding temperature is high the wear on the plates is excessive. No harm results from a low temperature except that the capacity of the battery is reduced.

NORMAN S. CAMPBELL.

Detroit, Mich.

If the plates were buckled when received, it would indicate an old battery. Buckled plates would account for the rise in temperature of the electrolyte, and the battery, owing to this condition, has a reduced capacity. The battery in this condition cannot be charged properly, although it will appear to be fully charged and will gas freely, especially if the sulphate forms between the active material and the grid. The active material contracts in the negative plate and closes up the pores; this reduces the active surface, the contact between the active material and the supporting grid is reduced, and when the battery is allowed to discharge too low, and stand in this condition, electrolytic action may take place on the surface of the material next to the grid, which will cause a layer of sulphate to form between the grid and the active material. The expansion of this layer of sulphate crowds the active material farther away from the grid, decreasing the contact and increasing the layer of sulphate; the result is the insulating of the active material.

If the active material in the negative plates has contracted, the separation from the grid can often be noticed. In this case, remove the positive plates and substitute dummy plates, made of thin sheets of lead, about 1/16 inch thick. The positive terminals from the charging leads are connected to the negative plates, the negative leads to the dummy plates. In charging the plates this way the negative plates become positive in effect. By reversing the polarity of the charging current the negative plates are reduced back to sponge lead. This reversing of the direction of the current tends to open the pores and bring the plates back to their normal capacity.

If a layer of sulphate is formed between the active material and the grid, the only way that I am aware of to reduce the sulphate is by burning it off. Charge the battery as rapidly as possible, without raising the temperature above 110 degrees Fahrenheit, and when it gases freely, reduce the charging current to three-fourths or two-thirds of the normal, and continue until the gas bubbles again appear; then again reduce the current to one-half the normal, and continue as before; give the battery a light discharge, and repeat the charging operation. This treatment will have to be performed several times. If the battery has been short-circuited by sediment filling up to the bottom of the plates, this charging operation will remedy it. The rate of discharge affects the temperature of the electrolyte, the higher the rate, the higher the temperature. The temperature also affects the capacity of the battery, the higher the temperature the greater the efficiency. It also increases the density. The battery, however, deteriorates rapidly if worked at a temperature above 100 degrees Fahrenheit.

E. G. TRUMBO.

East Las Vegas, N. M.

Effect of Superheated Steam on Cast Iron Fittings

Referring to the peculiar effect of superheated steam on cast-iron fittings, one example of which was shown in a recent number, a possible explanation of this action may lie in the fact that metallic iron at a high temperature (incandescence) has the property of decomposing steam, resulting in the formation of magnetic oxide of iron and free hydrogen. The action is very rapid when the iron is clean, but is retarded and becomes sluggish from the coating of oxide formed over the surface of the iron. I do not know that it has ever been determined whether this action ceases entirely if the temperature is reduced below a red heat, but it seems reasonable to assume that the high temperature of the steam would reduce the affinity of the atoms forming the water molecule, and assist the iron to dissociate them. The action could be very slow and still produce marked effects in the time the fitting in question was in service, i.e., three years.

The increase in the size of the fitting can be accounted for by the oxidation of the iron, but if this is found to be confined to a thin coating inside, another explanation would be the occlusion of the hydrogen by the cast iron. The great tenuity of hydrogen gas gives it great penetrative power, many solid metals, among them iron, being readily penetrated by it. When there is an attraction (perhaps a feeble chemical affinity) between hydrogen and the metal, the gas may become largely condensed in the pores of the casting. Whether this action results in any increase of bulk of the original metal I do not know, but a careful physical and chemical examination of the metal composing this casting would show what changes in structure and composition had occurred. In view of the great importance of such information it is to be hoped that a careful investigation will be made and the results published.

B. S. HUGHES.

Hamilton, O.

Corliss Valve Setting

Following are convenient rules for setting the valves of a Corliss engine: First remove the bonnet covering the ends of the valves. Reference marks will be found on the ends of the valves and seats, giving the positions of the working edges of the valves and parts. Reference marks will also be found on the wristplates and supporting stud. Turn the eccentric around on the shaft, and see whether the wristplate has equal travel on each side of a vertical center line. If it has not, equalize the travel by altering the length of the eccentric rod.

Next place the wristplate in mid-position with the dashpot plungers hooked up. By means of the wristplate rods give the steam valves the proper lap and the exhaust valves a negative lap, or opening about as indicated in the following table:

Piston Diameter. Inches.	Steam Lap. Inch.	Exhaust Opening. Inch.
12	1/4	3/32
14 - 16	5/16	1/32
18 - 22	3/8	1/8
24 - 28	1/2	3/32
30 - 36	3/4	1/8
38 - 42	5/8	1/8

To adjust the length of the dashpot rods, place the wristplate in one extreme position, as indicated by the reference marks. Adjust the length of the proper rod until the latch catches, with about 1/32 inch to spare, and repeat for the other extreme position. Should it be necessary to disturb the lengths of the wristplate rods, this operation must be attended to a second time.

Next, connect the hook rod to the wristplate. With the engine on the center, set the eccentric 90 degrees, plus the small angular advance necessary for the required lead, ahead of the crank, in the direction the engine is to run. If the lead is not the same with the engine on the other center correct with the wristplate rod. Then block the governor balls halfway up and see that the reach-rod lever is fastened at right angles to a line midway between the reach rods. Place the engine on, say, one-quarter stroke from the head end, and adjust the reach rod which trips the head-end valve until the valve is released. Repeat for the crank end. Final adjustment may be made with the engine running slowly.

Drop the governor balls to their lowest position, and adjust the safety projection to the knockoff cam so that, with the governor in this position, the valve cannot be opened by the wristplate motion.

H. L. DEAN.

Hyde Park, Mass.

Waste in a Power Plant

After reading C. R. McGahey's letter in a recent number, I do not wonder that the piping leaks, if the two boilers are connected as his illustration shows.

Regarding the size of pipe for a 28x48-inch engine, running at 100 revolutions per minute, it would be, according to the rule most used, as follows:

$$\frac{(28^2 \times 0.7854) \times 800}{6000} = 821;$$

$$\sqrt{\frac{821}{0.7854}} = 10.2,$$

or, say, a 10-inch pipe.

Nothing is said as to the speed of this engine, but it took the place of a 300-horsepower engine, which, at 100 revolutions per minute, would require only a 7½-inch pipe.

I have often seen a 300-horsepower engine with a 7-inch pipe carrying 500 horsepower, with a very small drop in pressure. I should say Mr. McGahey must be carrying, or trying to carry, a great deal more than 300 horsepower. He has an engine that with a mean pressure of 35 pounds and at 100 revolutions per minute, will carry 530 horsepower.

C. L. Johnson.

Mason City, Ia.

Effect of Scale in Boilers

In the December 8 number, F. Hilton Williams has something to say concerning the effect of scale in boilers. Mr. Williams may be glad to know that very complete information on this subject may be obtained in Bulletin 11 of the Engineering Experimental Station of the College of Engineering of the University of Illinois, Urbana, Ill.

This bulletin discusses the heat-transmission loss due to boiler scale and its relation to scale thickness, and covers a large series of experiments conducted by the experimental station under the supervision of Prof. E. C. Smith.

The statement commonly made that 1/16 of an inch means an increase in fuel consumption of from 12 to 15 per cent. is purely theoretical, and is based on the assumption that that thickness of scale covers the entire circumference of the tube, a condition which is seldom encountered in actual practice. On this subject, the bulletin in question states as follows: "Considering the scale of ordinary thickness—say of thickness varying up to ⅛ inch—the loss in heat transmission due to scale may vary in individual cases from insignificant amounts to as much as 10 or 12 per cent., and the loss increases somewhat with the thickness of the scale. Furthermore, the mechanical structure of the scale itself is of as much or more importance than the thickness in producing this loss."

In actual practice, a boiler with clean tubes will generate almost as much steam with a given quantity of fuel as two boilers of exactly the same size with the tubes coated with scale from ¼ to ½ inch thick.

H. E. Gansworth.

Buffalo, N. Y.

Removing the Cause of a Hot Crank Pin

The crank pin of an engine gave considerable trouble from heating. The third day after taking the plant to operate the works were shut down, and the writer thought it a good opportunity to look into the cause. Taking off the strap, the boxes still remained on the pin and it required considerable work to separate them. An examination showed that at some time the pin had worked itself loose, making the hole out of round. The engineer had wedged tin around the pin to hold it tight, after which he screwed up the nut at the back of the crank, assisted by a sledge hammer.

Another cause for the pin heating was that when this pin was originally put in there was a counterbore, requiring a collar on the pin to fit in the counterbore. The other engineer had turned the collar off so as to make the pin that much larger in order to fit in the hole better. This left a large opening in the crank. The inner collar on the brasses was also squared off in order to fit the new length of the pin.

In Fig. 1 is shown how the babbitt worked out and filled in the counterbore on the crank. As a consequence, every two weeks or so the brasses required refilling. This kept the pin hot all the time.

I found some ¼-inch copper wire and cut a piece large enough to make a ring to fill in the counterbore on the crank, Fig. 2. Then taking what was left, and putting a half ring in the boxes next to the crank, riveting them to the boxes, prevented the babbitt from working into the counterbore of the crank.

John Tyron.

Lynchburg, Va.

Remedying a Traveling Crane Trouble

Some time ago I had charge of the repair work in a large shop having an old-style crane that did first rate for small work. It was driven from one end, the motor being placed over the cage on the side of the crane.

When we undertook to handle a large casting, the drive end would start ahead of the opposite end and cause the work to sway back and forth, making it dangerous for the men to work on the floor. This ground the flanges off the wheels and sides off the track. As the floor for heavy work was situated directly under the out end, all the lifts were consequently made there. We decided to change the drive to the center, and also to put on a hand brake.

A track ran through the shop, and we had a box car pushed in and ran the crane directly over it. We then built a scaffold on top of the car high enough to work at the job. We took the motor and drive shaft down and laid out the bolt holes for the motor at the center of the crane. We also placed a new hanger to strengthen the drive shaft; also a 15-inch pulley on the shaft over the cage, and a hand brake with a foot lever to work in the cage. When ready, the crane ran a great deal better and without any swing, as both ends started at the same time; and with the brake, the crane could be stopped as quickly as the latest-style crane in the shop. Neither was there a strain on the shaft and gears, nor did the wheels grind and cut on the track.

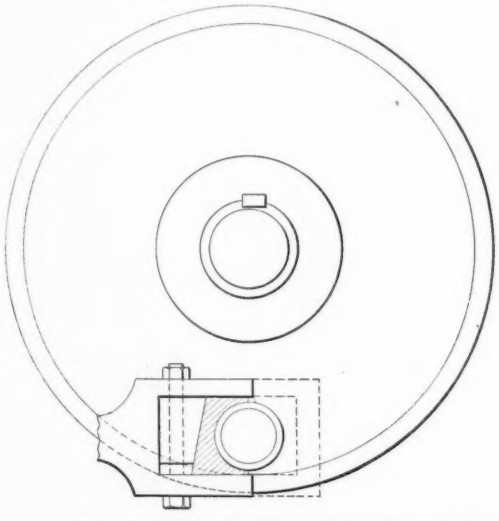


FIG. 1 SIDE AND SECTIONAL VIEWS OF BRASSES AND PIN

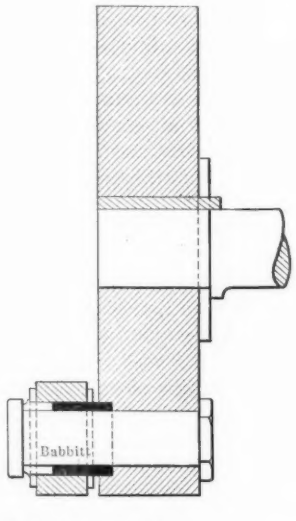


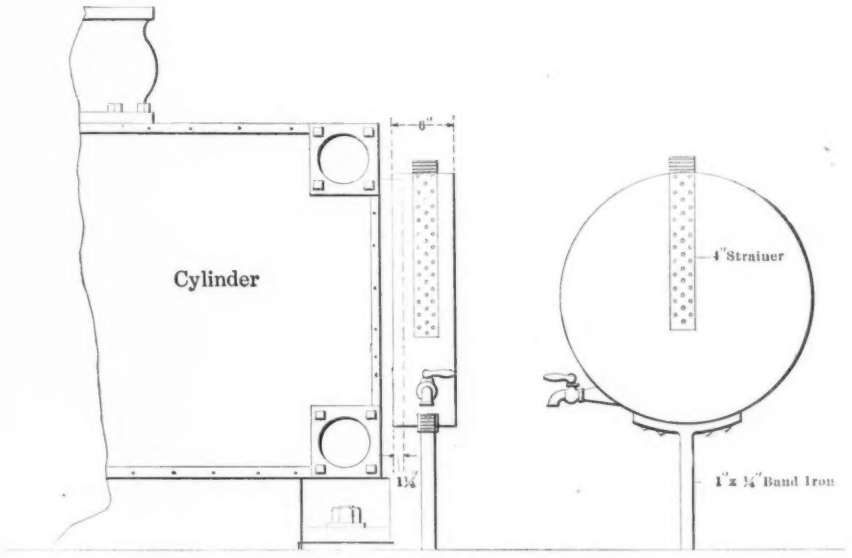
FIG. 2

S. J. Kelley.

Orange, N. J.

Cylinder Oil Tank Arrangement

The accompanying sketch shows a cylinder oil-tank arrangement I recently came across in a plant in St. Paul. It is attached to the engine cylinder as shown. It takes up but little room and does not disfigure the engine to any extent. It is made of galvanized iron and painted to match the color of the cylinder.



ARRANGEMENT OF OIL TANK ON CYLINDER

E. O. JEANSON.

St. Paul, Minn.

Eccentric Troubles

Recently a friend called my attention to the condition of one of his cross-compound Corliss engines. The eccentrics on the high-pressure side were chattering badly and running very hot, while the eccentrics on the low-pressure side were running smooth and cool. Oil was being fed at the rate of thirty-two drops per minute, the sight feeds delivering oil directly over the center of each steam valve. The receiver gage showed 27 pounds and never "flickered."

There being a hand-regulated cutoff on the low-pressure side governor, and being asked to see what I could do, I tried to change the receiver pressure, but the gage remained the same. We removed the gage and found it to be stuck fast. After repairing it and setting it with the other engine receiver gage, we replaced it and found that the receiver pressure was only 3 pounds. This was immediately changed to divide up the load. After taking a few cards we evened up the load very nicely, which helped the eccentric a great deal, but did not cure it. At the noon hour we took off the eccentric straps and found the eccentrics badly cut and grooved. The question confronting us was how to smooth them up without taking them off, and I decided to file them while in motion. We made a blank of No. 14 sheet iron and blanked the flange union on the high-pressure side of the receiver, or, in other words, the high-pressure exhaust into the receiver, took out the valves of the high-pressure cylinder and ran the low-pressure side with the equalizing valve. The engine was run very slowly and after four hours' work the eccentrics were in fine condition and calipered true. In the meantime the straps were scraped and calipered until they became smooth and true. When the engine was assembled we started off and a better running engine cannot be found.

The plant has in it three 36 and 70 by 60-inch cross-compound condensing engines, direct-connected to 500-volt generators, operating at a steam pressure of 175 pounds.

MANLEY J. MERRELL.

St. Louis, Mo.

Automatic Engine Stops

In an engine room where they were having trouble at the throttle the automatic stop was blamed. Upon investigation it was found that the engineer had packed the throttle-valve stem too tight, with the result that when the stop operated it was necessary to use force to open the valve. We overcame this trouble and eliminated all carelessness of engineers by getting metallic packing for the valve stem.

By having the stop directly connected to the main throttle it is operated every time the engine is started or stopped, thus insuring its being in working order.

When a speed limit is used it should be set to operate at five revolutions in excess of normal speed. The speed limits should also be tested at stated intervals.

A. RAUCH.

Pittsburg, Penn.

Moving Heavy Machinery

I read in one of the quite recent numbers A. G. Knight's method of moving heavy machinery on rollers up an incline. As he says, the method of moving heavy pieces on rollers is not new, but rolling it up an incline with pipe tongs and dispensing with tackle, jack or chuck is certainly new to me, and I have moved considerable heavy machinery. Suppose one of the men should fail to get a good grip on the pipe roller, and the others fail to hold it, where would the machinery land, and what would become of anyone who happened to stand in its downward course, if there were no tackle or chuck to stop it?

My advice would be to adopt some extra precaution in case of the possible slippage of the pipe tongs or wrenches.

WILLIAM S. LUCKENBACH.

Leavenworth, Kan.

Commutator Troubles

In replying to the request of Edward A. Young, in a recent issue, I advise that the brushes be given the correct tension on the commutator. If the tension is too light the brushes will jump and spark; if too heavy they will cut the commutator, which seems to be the trouble with Mr. Young's machine.

In the case of the D 62 unit, the heating of the commutator may be due to overload. Such heating is generally accompanied by excessive sparking which cannot be remedied, except by reducing the load. The trouble may also be due to the improper position of the brushes. The brushes may not be properly spaced around the commutator; each set of brushes should have the same relative position with regard to the respective pole tips.

A broken connection at the commutator leads or an armature coil broken will produce flashing at each revolution and the bars on each side of the one disconnected will be badly burned. The loose wire should be secured, or if broken, the commutator bars on each side of it should be soldered or bridged together as a temporary repair. As soon as possible a new coil should be put in.

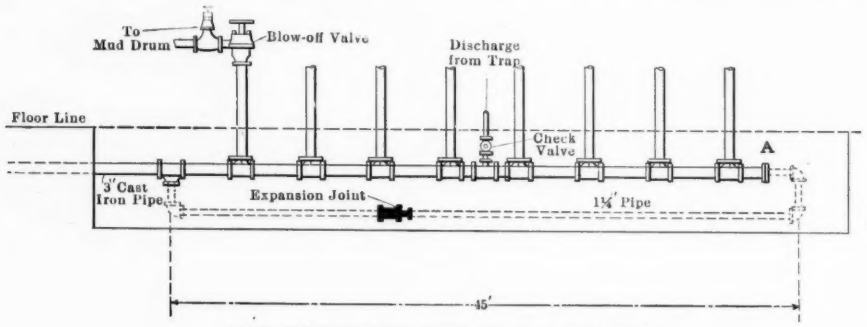
Sparking may also occur in a multipolar machine from the wearing away of the bearings, which produces eccentricity of the armature with respect to the field, and consequently unequal magnetic induction at different points. In some cases of worn bearings it requires a very close examination to detect this fault. If such is found to be the case, the bearings should be babbitted at the earliest possible opportunity, as the armature may strike the pole pieces, thus stripping the banding wires and probably cause the complete destruction of the windings.

GEORGE R. MCNATT.

Huntsville, Ala.

Blowoff Pipe Trouble Remedied

By the plan described herewith the writer got rid of at least 90 per cent. of the trouble from a very troublesome blow-off pipe. The full lines in the sketch show the 3-inch cast-iron pipe as first arranged. It was fitted with flange joints and tees to connect to the 2½-inch wrought-iron pipes, two of which connect to each mud-drum, there being four boilers. The discharge from two low-pressure steam traps enters about the middle of the pipe. The end *A* was blanked.



HOW BLOWOFF-PIPE TROUBLE WAS REMEDIED

For a year this pipe gave all kinds of trouble with broken tees, blown gaskets and, at one time, a split pipe. It was impossible to keep it tight more than two days. After a time, noticing that the breaks nearly all occurred near the closed end, I concluded that our trouble was caused by water hammer, and set out to find a remedy. Taking off the blank at *A*, we piped a 1¼-inch loop, as shown by the dotted lines. This pipe is 45 feet long and an expansion joint was inserted about the middle of its length, to take care of the expansion. This change has almost entirely cured the trouble. We have no more broken fittings, only an occasional gasket has to be replaced and we do not have to touch it for months at a time.

H. W. Ginaven.

Springfield, O.

To Etch Tools

The best way to mark names or initials on metal tools is to etch them. The mark is ineffaceable and easily done, with a little experience.

The first step in the process is to spread a thin layer of soap over the surface intended to be used. Next, with a sharp stick, or scratch awl, cut the name in the layer of soap, exposing the metal. Then drop into the letters enough of the following solution to commence an oxidizing action on the metal exposed: One ounce salt, 2 ounces copper sulphate (bluestone), and 1 quart of vinegar. A few drops will suffice, and a few trials will teach how long to let the solution work before wiping it off with a cloth.

This also makes a good solution for an open-circuit battery, for electric-bell and telephone work. Use copper and zinc terminals.

J. J. O'Brien.

Buffalo, N. Y.

Using Kerosene Oil in Boilers

In a recent issue a correspondent states that he cannot see any real gain in using kerosene oil for removing scale in steam boilers. Some years ago I had charge of a small steam plant in which was installed a second-hand boiler. It was in good condition, only it was badly scaled. After the boiler was set and bricked in I removed the scale with kerosene oil in the following manner:

All loose scale and sediment were removed from the tubes and shell and kerosene oil sprayed over the interior surfaces of the boiler, so that when the boiler was filled the oil would rise and come in contact with the under side of the tubes.

The top manhole was left open, and after filling the boiler to the proper level a slow fire was started and kept up for about ten hours. The boiler was then left to cool off over night and the next morning the water and loose scale were removed. The operation was repeated until most of the scale was taken out.

More kerosene was sprayed over the tubes and shell and the boiler was put in service for a week, meanwhile feeding kerosene with the feed water. Then the boiler was opened up and the loose scale removed.

When kerosene oil is used in a boiler, never place a torch or candle inside, until it has been thoroughly ventilated; better still, use an incandescent lamp.

Care should be exercised when using kerosene for removing old scale in steam boilers to open up the boiler a short time after using the oil, because the scale is liable to drop down on the fire sheets.

H. Jahnke.

Milwaukee, Wis.

An Emergency Piston in an Air Compressor

The accompanying description and illustration are of an emergency piston used in a disabled air compressor. The piston is from the steam cylinder of an 18 and 18¼ by 24-inch straight-line compressor. The original piston was wrecked when the heads of two follower bolts broke off and fell into the clearance space. The spider was split in two and the follower plate was broken.

The air from this compressor is in constant demand, so a temporary piston was constructed as follows:

We sheared out 12 plates of ⅓-inch tank steel in circles 18⅛ inches in diameter and bolted them together, as shown, by eighteen ¾-inch bolts. These were drawn up as tightly as possible and the piston put in a lathe. The taper hole in the hub was bored out to fit the piston rod and the piston turned down to the proper size. Three grooves were turned in the surface, ⅝ inch wide and 9/16 inch deep, and high-pressure spiral packing was forced into the grooves. The bolt heads and nuts projecting through the outside plates were turned off so as to make the piston 7 inches thick, the dimension of the broken piston.

The piston was then put on the rod, fitted into the cylinder and run for four or five days, when the new piston was put in. The temporary piston, when taken out, was in good shape, excepting the packing, which was pretty well used up.

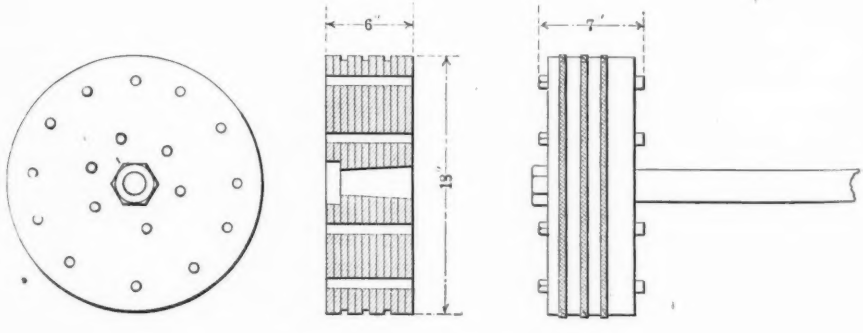


PLATE PISTON FOR AIR COMPRESSOR

The steam pressure was 160 pounds, with 100 degrees Fahrenheit superheat. The piston was rather heavy, but it did the work and no damage was done to the

cylinder; in fact, the surface was finely polished when taken out.

G. L. FALES.

Copperhill, Tenn.

Grout Foundation

I am operating a plant containing a 15x22-inch double engine furnishing power to a coal-washing plant. Six years ago the engine was set up on a concrete foundation, and later the top of the foundation crumbled under the bed plate to a depth of 4 inches. It became necessary to reline and level the engines, and at the same time rebabbitt the crank-shaft bearings. We began the job Friday night at 9 p.m., and had until 6 a.m. Monday morning in which to finish the work.

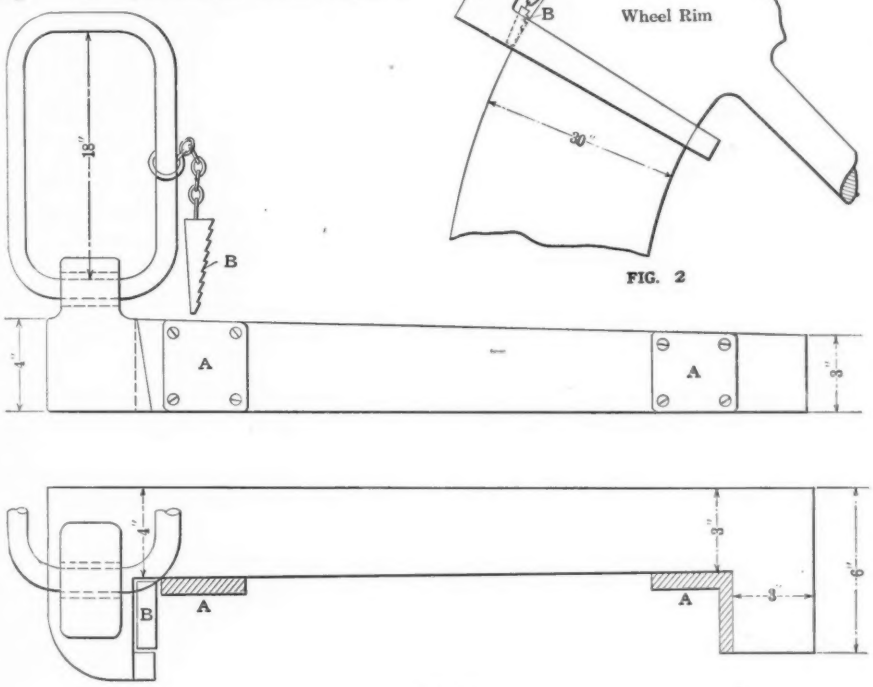


FIG. 1

I used 33⅓ per cent. Vulcanite portland cement and 66⅔ per cent. sand in a grout in a mold 4 inches deep on the foundation, after cutting and cleaning away all loose particles. After allowing 32 hours for the cement to become set we secured the engines with the sixteen 1¼-inch anchor bolts and started up on time Monday morning. After three days we again gave the anchor bolts about one-half turn, and today the engines are in place as solid as a rock.

J. J. KERR.

Dunbar, Penn.

Scraping Valves and Valve Seats

I desire information regarding scraping and fitting flat valves, of the type commonly known as the "Sweet" valve. Also, the successive steps, tools required, etc., to properly fit these valves.

S. A. ELLEARD.

Uniontown, Penn.

Engine Turning Device

Following is a description of a crane used to turn the flywheels of a vertical engine. The flywheels are 28 feet in diameter, 30 inches face, and weigh in all 160 tons. It was necessary, therefore, to make the hook good and strong. Fig. 1 shows side and top views of the rig, the small end of which is 3 inches square; the larger end is 4 inches square. The link is of 1½-inch iron and 18 inches long. The parts *A* have leather facings to prevent scratching the paint on the flywheel.

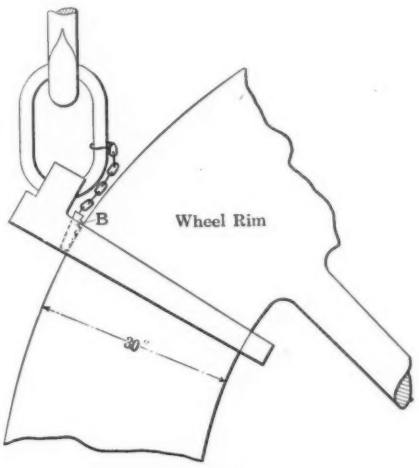


FIG. 2

The wedge *B*, Fig. 2, is made of tool steel, with teeth cut as shown in Fig. 3, which slant in the direction of the pull. The wedge is 6 inches long, 3½ inches wide and tapers from 2 inches to ¾ inch. It fits into position as shown in Fig. 4.

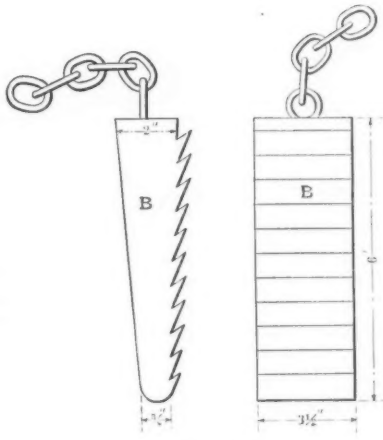


FIG. 3

One might suppose the rig would grip the rim of the wheel so tightly that it would stick to the wheel, but such is not the case, as it is only necessary to lower the crane hook, and the wedge will release, thus permitting the rig to slide down on the rim of the wheel, ready for a new grip.

E. H. LANE.

Kansas City, Mo.

Nuts and Wrenches

The skilled man can use a wrench in "any old way," and the other fellow cannot. Did you ever find yourself holding a hot piece of pipe in an awkward position and the other fellow with the monkey wrench, in his hurry to secure a threaded union, turning the wrench the wrong way, or opening the jaw in setting the wrench to size, instead of closing it?

Regarding the standard drop-forged wrenches, why is it that the double-end solid wrench is used so much? The writer has always preferred the single-ended wrench, it being much more convenient.

I notice that a large number of steamfitters are reversing the standard hexagon nut when putting up large steam fittings. I did not take kindly to the change at first, as it looks sloppy, but under the conditions I think it is a good thing to do. In the rush to get work out of the shop there are tons of large gate valves, tees, ells and pipe flanges that are not spot-faced for bolts, which should be done; consequently, the round or chamfered side of the nut adapts itself to the work, rather than the other or finished side.

CHARLES WILSON.

Hartford, Conn.

Driving Up a Bag in a Boiler

In a recent issue, Fred Windmiller describes an excellent way of driving up a bag in a return-tubular boiler, but the following method can be used where no foundry is handy and, very likely, no gas to supply a forge:

A bag developed and the makers cut the boiler out at a cost of about $100. The boiler next to it developed a bag a week later and as it was not as bad as the other it was decided to drive it back. A five-gallon gasolene brazing forge was used, a pressure of from 60 to 80 pounds being necessary to heat the plate. A short piece of 6-inch shaft was put in through the handhole to hold against the boiler shell. The bag was then heated and driven up with a sledge by working round and round the bag, gradually approaching the center.

The boiler, which has been inspected several times, has been in use for several years since and is said to be the best boiler in the battery of five.

The plant was not shut down as in the other case, and the boiler was out of use only three days, the expense amounting to the cost of ten gallons of gasolene and a helper for two days.

W. F. JOHNSON.

Bamberg, S. C.

A Peculiar Lighting Condition

If C. L. Greer, whose letter appeared in a recent issue of the paper, will remove the ground on the negative side of the circuit *C* (see reproduced sketch), he will find that the negative side of circuit *B* is grounded.

I would advise a new extension cord on the lamp used by the boiler washer. Then the lighting system should work properly.

E. B. AUSTIN.

Burlington, N. C.

Concerning C. L. Greer's inquiry, I would say that the following conditions might give rise to his trouble:

Should a dead ground exist at any point on the outside wire of circuit *B*, and a similar ground exist at a point on the outside wire of circuit *C*, the lights on circuit *C* would burn under the conditions he mentioned, namely, with the switch *A* closed on the exciter circuit, switches *B* and *C* closed and the circuit breaker open. The lamps on circuit *C* are then fed as follows: From the positive side of the direct-current machine to the lamps by way of the positive side of switch *C*, through the lamps to the ground, then

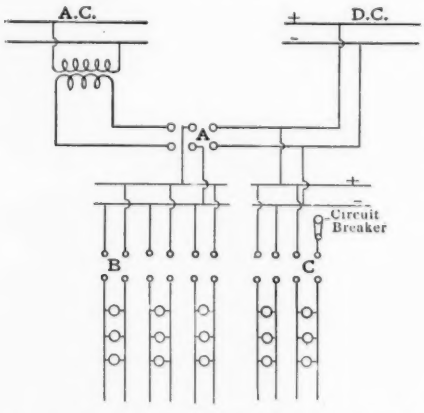


DIAGRAM OF WIRING FOR LIGHTING SYSTEM (REPRODUCED)

from ground on circuit *C* to the ground on circuit *B* and through the negative side of switch *B*, back to the direct-current machine by way of the negative side of switch *A*.

If we put the circuit breaker in it will remain there, the only part it plays is to supply an additional path for the current of the negative side, and the amount of current it will take will be proportional to its resistance and the resistance of the circuit through the grounds. In other words, we have a divided circuit of which one leg includes the circuit breaker and the other leg includes the grounds. If, now, the switch *A* is opened all of the circuit *C* must pass through the circuit breaker; this momentary rush of current may be sufficient to trip the same in the manner spoken of.

WALTER G. MULLEN.

Gloucester, Mass.

Air Compressor Accident

Quite recently, in one of the largest railroad shops in the middle West there was a serious air-compressor explosion which wrecked the tanks, engine and hundreds of feet of pipe and tore great holes in the walls of the building.

The accident was a progressive one, the first trouble being the explosion of about a hundred feet of underground air pipe in the yards, which so lowered the tank pressure as to cause the engine, which was air-controlled only, to run away and burst the flywheel, which was directly in line with a battery of large boilers. They, however, escaped injury.

The primary cause was undoubtedly oil in the pipes, which became volatilized and fired, either by heat or by electricity, the former being more likely.

There are three lessons to be learned from this accident, of which the most important is that an air-compressor engine should not be controlled by air alone, but should be fitted with an auxiliary governor which will act as soon as the speed rises above a certain point. In this way an accident to the tanks or piping, causing a sudden lowering of the pressure to a dangerous degree, would not cause the engine to race. The lowering of the pressure need not necessarily be caused by an explosion, but the giving way of a pipe, valve or tank from any cause would have the same effect.

The second lesson is one that is being driven home by dozens of accidents all over the country, and that is, *keep an excessive amount of oil out of the system.*

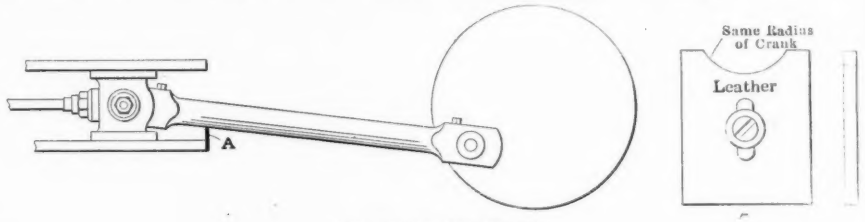
The third and last lesson is one that is seldom needed, but which in this case was disregarded, though fortunately without serious result. It is that no engine should be so set that the bursting of the flywheel would be apt to crush the boilers.

ETHAN VIALL.

Decatur, Ill.

Preventing a Crank from Throwing Oil

An engineer experienced a great deal of trouble from oil thrown by the crank of a Corliss engine. He tried a number of methods of getting rid of the nuisance, but had not been successful.



OIL GUARD ON GUIDE

The idea of fastening a wiper to a wire, so that it would wipe the surplus oil off as the crank went past the bottom developed. This idea resulted in the application of a wiper, as shown in the illustration. It was cut out of leather and fastened with a screw and washer to the end of the guide. After this wiper was put on and adjusted so that it touched the rod lightly at each revolution, the oil-throwing nuisance completely disappeared.

W. L. WHITMARSH.

Phenix, R. I.

A Lead Brush

Soon after I took charge of the plant I now have, one of the carbon brushes of a two-brush four-pole shunt-wound motor broke in half. As there was not enough left to be of any use, I got some lead and cast a brush. I then filed it up and sandpapered it to fit the commutator surface. I had no trouble for the rest of the shift and the next morning I replaced it with a new carbon brush.

C. R. MOURE.

Exeter, South Australia.

Belt Ruined by Oil

The following experience was a costly one for my employer, although he never discovered the cause. A 6-inch belt gave trouble and the office was convinced that a larger belt and pulleys were needed. After the belt was put in place, the superintendent gave me a gallon of neatsfoot oil and told me to soak the belt with it. Although I knew better, I brushed the oil on until the belt was as limber as a rag. Then it began to stretch, and a heavy idler pulley was put up.

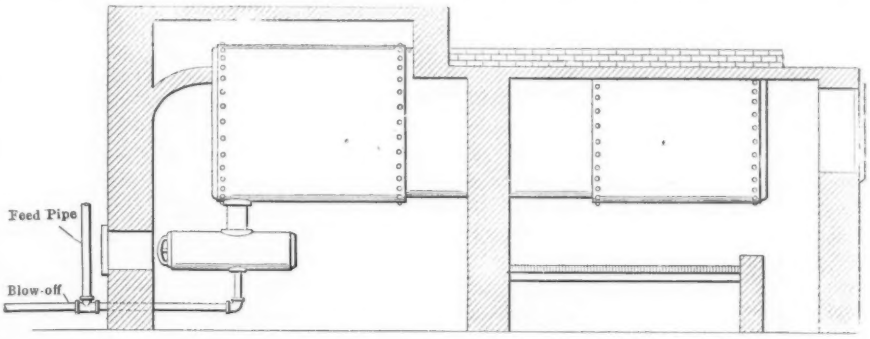
The oil so injured the glued joints that they had to be pegged and riveted repeatedly. Finally the belt parted and wound between the pulley and hanger. It was so badly damaged that a new one was necessary.

CHARLES HAEUSSER.

Albany, N. Y.

Boiler Setting

S. Kirlin's improvement on Mr. Wheeler's idea of a boiler setting as illustrated in a recent number, appears favorable in many respects, although I should arrange details slightly differently. The soot-blower door, for instance, could be located



MR. CEDERBLOM'S SUGGESTION FOR BOILER SETTING

to better advantage in the opposite end so the flues could be blown out with instead of against the draft. As it is, the soot will be blown out in the fire room if too much pressure is applied.

Where the blowoff pipe now enters the boiler I would have a good-sized mud drum connected to the boiler by a 6- or 8-inch nipple, and pump the feed water into this drum through the blowoff connection, as shown in the accompanying illustration. The arrangement would be safe from burning out, and would hold water at such a high temperature that most of the scale-forming matter in the feed water would be precipitated in the drum, where it can do no harm and is easily removed.

R. CEDERBLOM.

Gary, Ind.

Repairing Commutators

The "flashing over" or excessive sparking of a commutator may produce a minute cavity in the commutator insulation, which, from time to time, becomes filled with a conductive material from the brushes, particularly where a lubricant has been used. When enough has accumulated in the spot to become a fair conductor, and a current passes through it from bar to bar, the mass becomes incandescent, immediately burns out, and with it a certain amount of commutator insulation.

At intervals the process is repeated. Often the original cause of this defect is obscure and beyond prevention by the man in charge. This condition, however arising, is always recognized by a reddish-yellow spark forming a momentary ring of fire around or partly around the commutator and always recurring at the same place. The damaged spot becomes worse, and unless attention is given will invariably end in serious damage to the commutator, and often to the armature coils.

In order to properly examine a commutator in this condition ample light must be provided. Each segment must be thoroughly inspected and the faulty places marked. When a burned spot is located it must be scraped and cleaned out until absolutely no trace of carbonized material remains. This is by no means an easy task, but the same may be facilitated by the use of a special tool which is conveniently made from a 4-inch piece of hack-saw blade, one end being ground to a point similar to a shaper tool. This end is also made just thin enough to enter between the bars. If this tool is given a sharp, square cutting edge no difficulty will be experienced in scraping the mica insulation clean.

After the cavity is thoroughly cleaned it should be refilled with either silicate of soda, or silicate of soda and powdered glass, plaster of paris, or plaster of paris and shellac. A mixture which the writer has used successfully is silicate of soda with calcium carbonate, more commonly called powdered chalk. They are in the right proportion when mixed to a thick paste. The latter is packed into the cavity and a small surplus left on top to be afterward smoothed down with sandpaper. These materials combine chemically, forming calcium-silicate and become very hard in a few hours.

Where a burnout is deep enough, or where it occurs at the end of the commutator, new mica may be cut to approximately fit the part, the cavity coated with moderately thick shellac and the mica tightly driven in; the projecting edges being trimmed off afterward.

Where a machine repaired in this manner can only be shut down a couple of hours, hot irons applied to the locality repaired will hasten the drying out of the shellac.

LEONARD WORK.

Pittsburg, Penn.

Lamp Wiring Diagram Wanted

Can any of the readers suggest a wiring diagram for throwing, say, three battery lamps from parallel to series and *vice versa*, using only a standard switch or switches?

E. J. WILLIAMS.

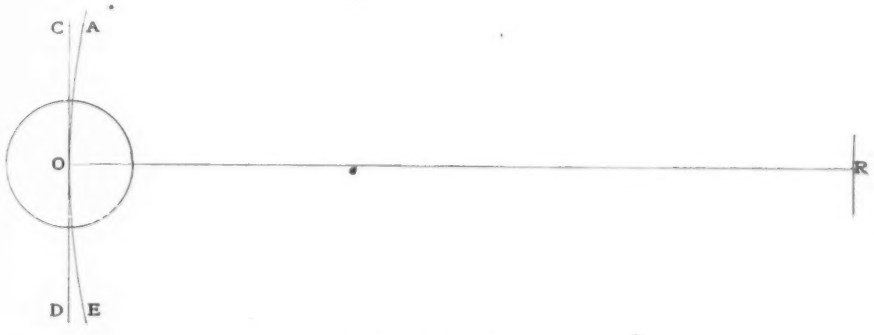
Cleveland, O.

Laying Out an Eccentric Keyway

In a recent number, John Gasteiner gives a simple method of determining an eccentric keyway which, I believe, is not quite correct, as the angularity of the eccentric rod has not been considered.

Let the circle (see illustration) denote the throw of the eccentric and $O\,R$ the length of the eccentric rod, which in this instance is six times the throw. The arc $A\,O\,E$ would be the path of the eccentric rod through the center of the shaft, and the line $O\,A$ the position of the eccentric at mid-stroke, when the valve is in its central position. Mr. Gasteiner takes the vertical line $C\,D$ for this position, and his keyway would be out as much as the angle $C\,O\,A$, or about 3 degrees.

If this was corrected, the keyway, so determined, would be right only if the rocker arm or wristplate pin were level with the center line of the engine. As it is sometimes higher or lower, corrections would have to be made accordingly.



FOR LAYING OUT AN ECCENTRIC KEYWAY

If I had the old and new shafts and a surface plate to place them, I would prefer to lay out the keyways with the surface gage. There is always some part of the keyway intact enough to find its accurate center.

H. WIEGAND.

Indianapolis, Ind.

Low Pressure Turbines and Steam Engines*

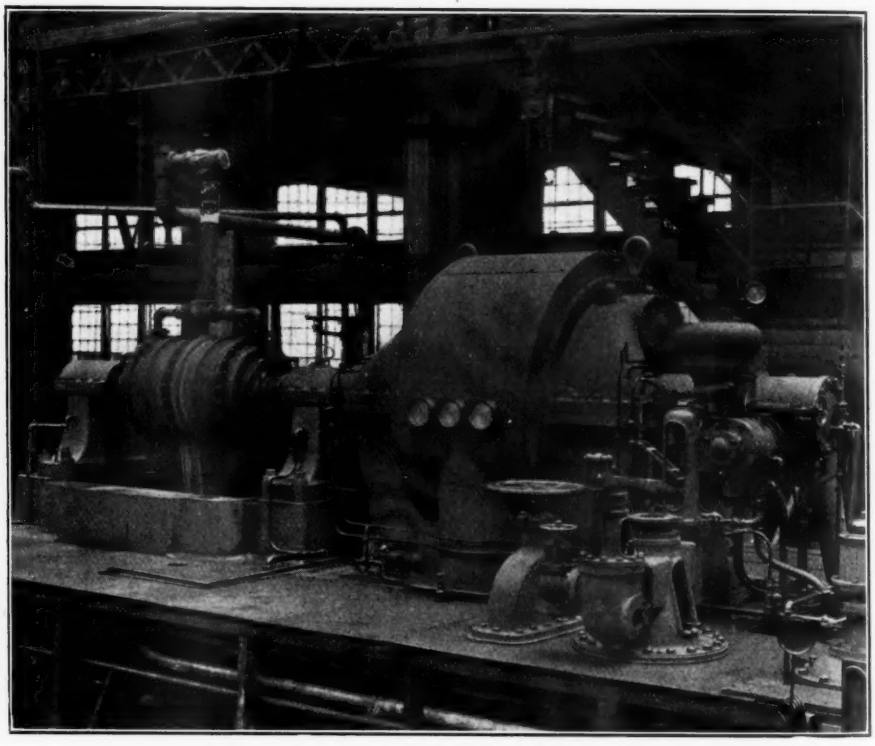
Advantages to be Obtained in a Combined Plant; Flexibility of Application a Turbine Characteristic; Efficiency Ratio Possible

BY J. R. BIBBINS

Both the standard types of prime mover, the reciprocating engine and the steam turbine, have distinct fields in which their highest efficiencies are respectively obtainable. The steam engine finds its most efficient territory in the higher pressure ranges above atmosphere, while the steam turbine works to best advantage in the lower stages. This, of course, does not carry the inference that the engine cannot benefit substantially from high vacuum, nor *vice versa,* the turbine from high boiler pressure, for the advantages of each are well known. In the engine, the losses due to condensation and reëvaporation on the cylinder walls during each consecutive cycle are large; in the turbine there is no cyclic change, and therefore no such losses, comparatively speaking, as a fairly constant temperature and pressure obtain at any given point in the expansion range. In the engine the mechanical friction of the enormous sizes of cylinder necessary to accommodate the lower expansion ranges constitutes an effective barrier; in the turbine the lower ranges are obtained with comparative ease and without incurring excessive losses, mechanical or thermal.

A good Corliss engine will give the best efficiency** (72 per cent. at normal load in the case to be discussed later) when operating noncondensing against exhaust pressures of from 15 to 20 pounds absolute. Certainly cylinder ratios of 1 to 2.5 to 3.5 will do so. Similarly, the steam turbine expanding from 15 to 25 pounds absolute down will show a maximum efficiency ratio as high as 73 per cent. for moderate vacuum, and commercial guarantees are today made above 70 per cent., a fact which speaks for itself. Thus, it occurs that the combination engine-turbine plant will show an overall efficiency ratio (65 to 75 per cent. of the ideal cycle) considerably in excess of either an engine or complete-expansion turbine unit running alone, which can hardly do better than 65 per cent. In the case treated later, the Rankine cycle efficiency of the combined unit was found to be 69.3 per cent. at normal load.

The pioneer work (about 1890) of C. A. Parsons, to whom we are all indebted, has brought about so thorough a discussion of the marine problem as to take definite form in the recent decision to equip the two monster transatlantic liners with combined engine and low-pressure turbine plants. Professor Rateau's work in steel mill and mine hoisting has also resulted in the practical application of low-pressure turbines in connection with the steam-regenerative principle, permitting the turbines to operate constantly, using the exhaust steam from engines intermittently operated. His work has been brought to our notice in this country by H. H. Waite, in discussing regenerative turbine application to steel mills.† J. W. Kirkland‡ has introduced the subject of low-pressure turbines in light and power plants. And it is this line of thought that it is desired to enlarge upon in the present paper.



WESTINGHOUSE DOUBLE-FLOW TURBINE ON TESTING FLOOR

Application

There are two general classes of service in which the low-pressure turbine finds effective field for application:

Class A—Supply of steam intermittent and widely varying in quantity. For example, rolling mills, for blooms, plate, sheet, wire, rail and structural shapes, steam hammers and hoisting engines. All of these involve the regenerative principle, requiring a careful study of the time element in supply and demand, generally resolving into a special problem for each individual installation.

Class B—Nonintermittent supply without regeneration. This class embraces central power stations for lighting, traction or for factory drive, and may be discussed as a general problem of power extension where the widely varying plant conditions may be summarized as follows:

(1) Good engine design; fair operating efficiency. Increase in capacity necessary.

(2) Inefficient engines, condensing or noncondensing, improvement in operating economy or increase in capacity necessary.

(3) Present condensing plant unsuitable or inefficient.

(4) Plant location; where water supply is limited, unsuitable or costly, for example, enforced noncondensing operation.

*Paper read before the Canadian Society of Civil Engineers, Montreal, Can., November 26, 1908.

**It is understood that the term efficiency in this case refers to efficiency ratio in per cent. of the Rankine-Clausius cycle, i.e., efficiency in per cent. of available energy in the steam within the range of pressures, not steam consumption.

†American Institute of Electrical Engineers, December, 1907.

‡National Electric Light Association, June, 1908.

(5) High cost of fuel.

Given a reciprocating-engine plant of serviceable construction, along what lines shall needed power extension be made?

(1) By installing more reciprocating units of the same type and operating under the same conditions.

(2) By installing more efficient complete-expansion turbines with suitable auxiliaries.

(3) By utilizing the low-pressure turbine principle to render the present plant more efficient.

Primarily, the problem before us is that of Class B, (1) and (2), *improving the efficiency of a given reciprocating-engine plant*, which may be in the best physical shape, but operating under unsuitable conditions. The importance of this subject will at once be appreciated when we reflect that a plant of noncondensing engines may be changed over to reduce its water rate from 30 or 35 pounds per kilowatt-hour to 15 or 18 pounds per kilowatt-hour in comparatively small sizes; in other words, for the same expenditure of coal and water, a net increase in power of from 80 to 100 per cent. may be realized, depending upon the type of equipment. And the resulting cost of power is reduced in the same proportions. In the case later discussed, a minimum water rate of 15.8 pounds per kilowatt-hour (150 pounds dry saturated steam to 28 inches vacuum) is obtainable from an engine giving 28.5 pounds per kilowatt-hour noncondensing, and 20.05 pounds per kilowatt-hour condensing, with an increase in rated capacity of 90 per cent.; maximum, 100 per cent. This is equivalent to 9.9 pounds per indicated horsepower-hour, or an efficiency ratio of 75 per cent. indicated, 68 per cent. brake.

Turbine Tests

Two series of tests*, Figs. 1 and 2, will serve to illustrate the possibilities of economy and capacity: Fig. 1 represents tests at several different loads and varying inlet pressures, all on approximately dry-saturated steam and 27.5 inches vacuum. Although a few of the original observations were slightly irrational, this was due to the difficulty of maintaining exact vacuum, and when corrected fell well into line. Note that these tests, Fig. 1, were all conducted at inlet pressures below atmosphere, but the characteristic for higher pressures is the same, a straight line, as has been proved by other tests carried as high as 30 pounds absolute. Thus, at 15 pounds inlet pressure, the water rate is approximately 23.6 pounds per brake horsepower (33.2 pounds per kilowatt-hour) and at 20 pounds inlet pressure, about 21 pounds per brake horsepower (30 pounds per kilowatt-hour).

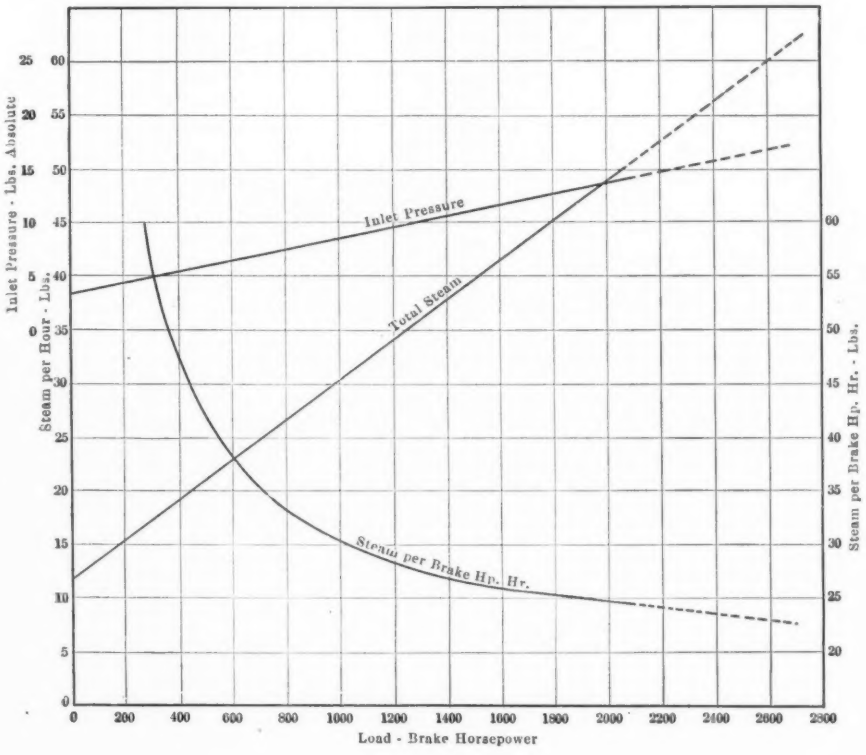

Inlet Pressure - Lbs. Absolute
Steam per Hour - Lbs.
Steam per Brake Hp. Hr. - Lbs.
Inlet Pressure
Total Steam
Steam per Brake Hp. Hr.
Load - Brake Horsepower

FIG. 1

The effect of higher inlet pressures and varying vacua is well shown by Fig. 2, a series of tests upon the low-pressure section of a 2000-horsepower lighting turbine for the Interborough Rapid Transit Company in 1902. This machine is of the single-flow design, the high-pressure section expanding down to about atmosphere and the low-pressure section below. Note that the water lines are virtually straight up to the maximum initial pressure, 30 pounds, and slightly divergent for varying vacua. This range of inlet pressure represents quite closely the actual range of operation in a combined engine-turbine plant. The result of tests on this machine, the first one of the type built for commercial service, shows an efficiency ratio of about 70 per cent. at 15 pounds absolute inlet pressure and 27 inches vacuum. And this may be improved upon if it is considered expedient to design for higher vacuum.

Characteristics of Low-pressure Turbine

From a thermodynamic standpoint, the low-pressure turbine is the exact counterpart of the complete expansion turbine, and it possesses the same characteristics shown by Fig. 2. As in the high-pressure turbine, the line of total consumption per hour, or water line**, is practically straight, resulting in a constantly decreasing water-rate curve. The power developed by this machine, increased in proportion to the inlet pressure, barring the small friction drop throughout the machine at no load. As this type of machine employs no mechanism in the shape of overload or secondary valves, this

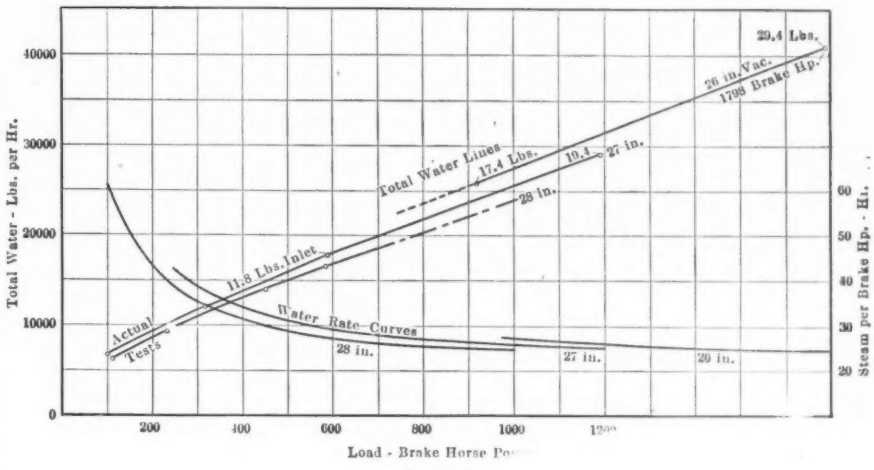


FIG. 2

*Owing to the author's special familiarity with developments at East Pittsburg, these data refer entirely to results obtained from Westinghouse apparatus.

**Sometimes called the Willans law.

would be expected, and the water-rate curve is necessarily an equilateral hyperbola. The low-pressure turbine may be regarded as the third cylinder of a triple-expansion system, and is equivalent to such cylinder fitted with *fixed cutoff*. In other words, it must have a definite initial pressure to enable it to pass a given weight of steam. This necessitates a careful study of engine-cylinder proportions and valve movements. For it occurs that when direct-connected to an engine, the release pressure in the low-pressure engine cylinder may be well above the initial pressure required by the turbine, or considerably below it, depending upon whether the load is heavy or light. In the first case a large receiver drop would ensue between engine and turbine, and in the second a serious loop in the low-pressure diagram. Therefore, the type of engine, cylinder ratio, the cutoff and the average- and maximum-load demand must be known before any rational decision can be made as to the proper size of turbine to install and the resulting distribution of load predicted. However, should errors be made in the calculations or determinations of the low-pressure turbine characteristics, the same may be easily rectified by a slight change in the angle of the blades, requiring but a very small expenditure.

Engine Characteristics

Assuming a normal design of Corliss compound engine, there are two methods of governing which may come under consideration:

(a) High-pressure cutoff variable; low-pressure fixed.

(b) Parallel cutoff, i.e., both high-pressure and low-pressure variable in the same direction, increasing with the load.

The parallel system is widely employed in Corliss practice to maintain an equalization of work in the two cylinders. It is difficult, however, to avoid loops in the low-pressure cards at light loads (noncondensing), as the low-pressure cylinder expands below the exhaust pressure. In case (a) the low-pressure cutoff is deliberately fixed far enough in advance to eliminate the low-pressure loop in the lower ranges of load anticipated. But this system has the disadvantage of causing a great disparity† in loading cylinders.

A point worth noting is that in lightly loaded plants where large increase is anticipated, the low-pressure loop may be to some degree avoided by omitting a few rows of blades, thus enabling the turbine to pass the same quantity of steam at a lower inlet pressure. Ordinarily two rows will be sufficient and these may be rereplaced later when normal operation is resumed.

†Thus with the low-pressure cutoff fixed at 75 per cent. of the stroke and the high-pressure as short as 15 per cent., the engine would deliver steam to the turbine at 8 pounds absolute and without loop. But on maximum load with high-pressure cutoff at 75 and 25 pounds back pressure, the ratio of work in the two cylinders would be about 2 to 1.

This brief discussion will serve to illustrate the necessity of a careful study of the engine problem. In designing a plant for a given loading factor, say, 75 per cent. average and 150 per cent. maximum rating, the point of rating of the combined unit may be regarded as corresponding to the point where the engine is operating at its best economy, noncondensing, for the combined plant virtually retains the characteristics of the engine equipment.

Combined Plant

The effect of the various factors outlined may be best illustrated from Figs. 3 and 4, which have been prepared to exemplify the principles of design for a 2000-kilowatt installation suited to a 50 per cent. overload, or thereabout. Fig. 3 shows only the water lines, from which are derived the respective water-rate curves, Fig. 4. These water lines cover the following conditions:

(a) Engine alone condensing, 26 inches vacuum.

(b) Engine alone noncondensing, 17 pounds absolute back pressure.

(c) Low-pressure turbine alone, 28 inches vacuum, variable inlet pressure.

(d) Engine noncondensing with variable back pressure, resulting from its connection to the turbine.

(e) Combined engine and turbine system, 28 inches vacuum.

Of the above, (a), (b) and (c) were obtained by actual data. The combined curve (d) must be found graphically from the characteristic curves of engine and turbine, and the final curve (e) by combining (c) and (d). These water lines, Fig. 3, serve to illustrate the difference between the Willans characteristic for turbine (c) and an engine (a) (b) governed by cutoff. One is a straight line, the other a curve. The turbine has no point of lowest water rate other than maximum load; the engine ordinarily does its best at rating or under. It is usual practice to rate an engine at its point of lowest steam consumption. This may be found from the water lines as the point of tangency of a radial line from the origin. Thus, this engine running condensing shows its best economy at about 1000 kilowatts, and noncondensing at about 1200 kilowatts, which is entirely rational. On the other hand, the resultant engine curve (d) shows a best point of economy slightly under 900 kilowatts, due to the influence of the variable back pressure. Therefore, the turbine should be designed to pass just the amount of steam required at a back pressure corresponding approximately to this point of best engine economy, noncondensing. Care must be taken, however, in adapting the turbine to the engine, to avoid any condition that will cause excessive pressures on engine crank pins and bearings.

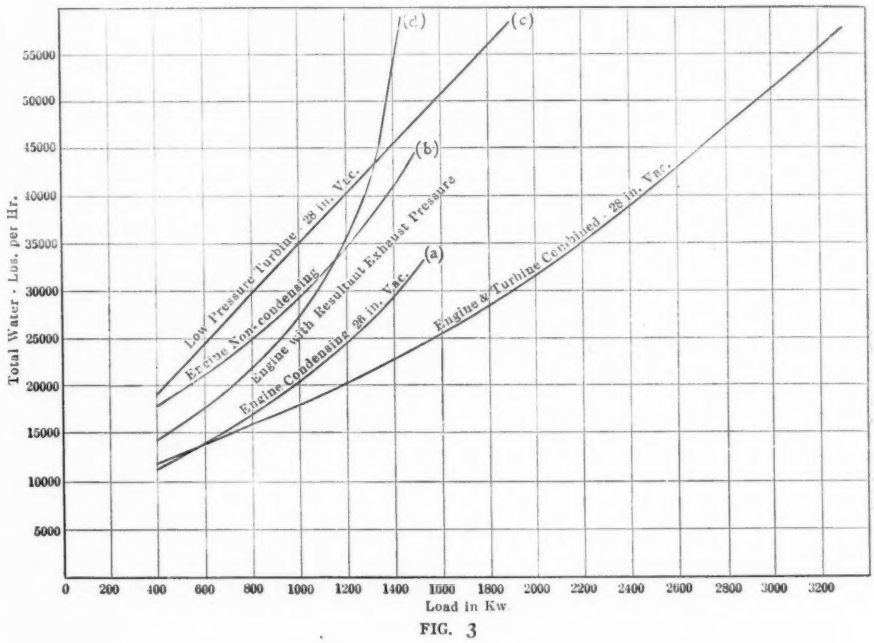


FIG. 3

This point of safe pressures is mentioned because of a tendency permanently to overload the engine in the desire to produce a very low water rate. It should not be considered good practice to operate an engine on pressure much in excess of 50 per cent. of that for which it was designed‡. A recent study of a combined plant that has been widely discussed shows that the engine had been forced to a mean effective pressure of 56 pounds referred to the low-pressure cylinder. In our typical study, Figs. 3 and 4, it has been thought best to take an engine of normal proportions, as found in many lighting and traction plants (cylinder ratio 1 to 3¾) rather than a ratio more suited to efficient noncondensing operation; for example, 1 to 2.5 or 3. There-

‡In average practice, a compound Corliss engine (condensing) would be designed for about 30 pounds mean effective pressure at rating, and should not operate with mean effective pressure much over 45 pounds (referred to low-pressure cylinder).

fore, the results may be considered conservative in this respect. The design is based on, first, an engine rating (best) of about 33 pounds mean effective pressure referred to the low-pressure cylinder, 165 pounds absolute boiler pressure and 17 pounds absolute back pressure, and, second, allowing 1 pound drop between machines, a turbine passing the engine room at 16 pounds inlet pressure, 28 inches vacuum. The combined plant, 2000 kilowatts, has an overload capacity of 50 per cent. with some excess margin.

Examining the water-rate curves, Fig. 4, we find that the engine gives an economy of 20.05 pounds per kilowatt-hour condensing, 28.31 pounds per kilowatt-hour noncondensing, for a normal load of 1000 kilowatts in each case; but in combination with the turbine, a maximum water rate of 15.8 pounds per kilowatt-hour.

Curve (e^1), Fig. 4, has been derived from (e) for comparison of water rates of combined plant and condensing engine on the *same basis of rating*, i.e., equivalent to curve (e) at half scale. Thus, at rating, the combined plant shows an improvement of 22 per cent. in water rate. At light loads, however (500 kilowatts), the combined plant ceases to be as efficient as the engine running alone condensing. The point of equal economy is, of course, somewhat variable, as it is difficult to locate it accurately with two curves at such an acute angle; but it immediately suggests that in the practical operation of a combined plant, it would be desirable to shut down the low-pressure turbine when the load falls below 30 per cent. rating, for example, and operate the engine alone.

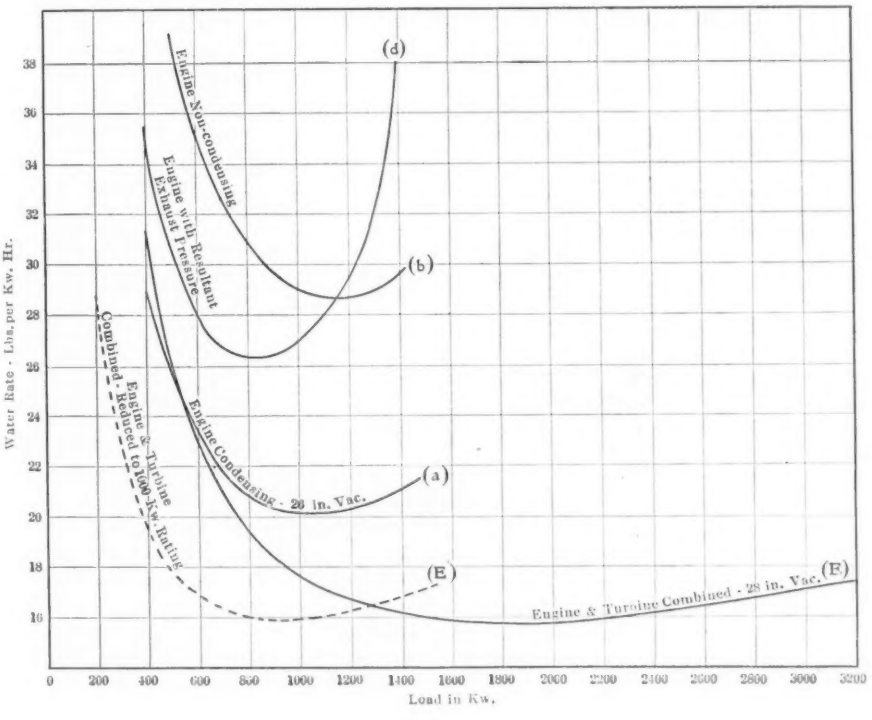


FIG. 4

Governing

For a study of governing the various classes of service may be summarized as follows:

Class A—Turbine electrically locked with engine; that is, serving the same busbars.

(1) Turbine taking all of the engine steam. No governor required. Load on turbine varies with engine load.

(2) Turbine taking part of the engine steam. No governor required. Output remains practically constant with uniform pressure in exhaust mains, due to excess supply of exhaust steam.

In both of these cases atmospheric relief should be provided (if only to enable the engine to operate while the turbine is shut down) and, of course, a hand-throttle valve.

Class B—Turbine electrically independent of engine; that is, serving separate bus; for example, lighting only, engines on traction bus.

(3) Turbine taking all or part of engine steam. Governor required in case of intermittent supply.

With momentary deficiencies occurring only *infrequently*, a reducing valve must be used for auxiliary live-steam supply, also in case of deficiencies of *long duration*; but with rapidly fluctuating supply averaging in excess of the demand, a regenerator *may* become profitable, or its equivalent in electrical storage may be used in direct-current systems.

In all of these cases a safety stop is obviously essential, simply for insurance against possible overspeeding. In Class A (2), for example, should the circuit open with the turbine under load, the safety alone would prevent disaster. The automatic safety stop may operate either a butterfly valve or a positive closing throttle.

Gary Installation

A typical example of low-pressure turbine application is found in the plant of the United States Coal and Coke Company, at Gary, W. Va. It operates the mining property serving hoists, pumps, blowers, lights, etc. The plant contains two 24 and 44 by 42 Corliss engines, 750 kilowatts, one 1000-kilowatt complete-expansion steam turbine and a 1000-kilowatt low-pressure steam turbine, both of the Parsons type. These turbines are served by three cooling-tower units, fan-driven, each 24 feet in diameter and 25 feet high. Two of these units serve the low-pressure turbine and one the high-pressure turbine. The following figures roughly indicate the normal operation of the generating units from readings taken October 7, 1908:

Output of two Corliss engines	1400 kw
Output of low-pressure turbine	1200 kw.
Steam pressure (gage)	150 lbs.
Vacuum, L P. turbine (rfd. to 30 in.).	25.8 in.
Temperature of injection	88 deg.
Temperature of air	85 deg.
Cooling in tower	31 deg.

Thus the low-pressure turbine carried nearly half the total load on less than 26 inches vacuum, and would have carried more than 1500 kilowatts on 28 inches vacuum, with better condensing conditions.

Auxiliaries

Inasmuch as the turbine is so dependent upon auxiliaries, it is pertinent to point out some facts in this regard. If we compare the ideal water rate of a turbine expanding from atmosphere down to various vacua, we shall find that while the ideal machine improves continuously down to the lowest condenser pressures, the actual turbine cannot make as good use of the last inch or two of vacuum as in other parts of the expansion range; in other words, we may expect the highest efficiency in moderate ranges of vacua. This is in entire agreement with high-pressure turbine work, as the author has endeavored to point out many times before. However, assuming that the turbine improves 5 per cent. per inch of vacuum around 27 inches, it is plain that an efficient condenser is very desirable but with warm circulating water it is not always possible to obtain the vacuum desired. This is due almost always to the inability of the condenser to work with a *small enough temperature difference between steam and discharge water*. A condenser may be regarded as a heater, and its effectiveness is entirely dependent upon its ability to deliver water heated as nearly as possible to the temperature of the steam. This is of the utmost importance in plants where cooling towers are necessary. And at this point may be emphasized the fact that the cooling tower is rapidly receiving the recognition it deserves. This has been brought about by the recent development of more efficient condensing apparatus.

A good surface condenser should operate within 15 degrees difference between the temperature of the steam and discharge water; a good barometric jet within 10 degrees; yet we find that twice this difference is tolerated in modern power plants as supposedly good performance. This is the secret of the poor vacua against which turbine builders are obliged to struggle in designing machines for better conditions.

There are now on the market condensers of the jet type which are able to operate within 2 to 5 degrees of the steam temperature and without unusually bulky or wasteful auxiliaries. This considerably reduces the quantity of cooling water necessary to condense a given amount of steam; in other words, makes possible a higher vacuum with a given temperature of water. For example, assuming a cooling tower able to cool down to the temperature of the air, what vacuum will it be possible to maintain with 75 degrees water? A perfect condenser (with no temperature difference between steam and discharge water) would require about 220 volumes of cooling water for 29 inches vacuum. For 28 inches vacuum it would require 35 volumes. An efficient condenser of the jet type, working within 5 degrees of the steam temperature, can maintain 28 inches with 43 volumes of water. An ordinary jet condenser, working on 10 degrees difference, will require 57 volumes to maintain 28 inches, while the ordinary surface condenser, working for 20 degrees difference, cannot maintain 28 inches except by using an impracticable amount of water, 140 volumes.

The more efficient jet type is thus responsible for reducing the quantity of cooling water to one-third of that required for the average surface type.

In cooling-tower practice, where extra power is required to lift these large volumes, this is evidently of the highest importance, for the increase in auxiliary plant may more than offset the benefits of the increased vacuum. Therefore, the determination of the *most economical vacuum* for a given plant involves a study of the plant economy at various vacua, the power consumption of auxiliaries and the operating and fixed charges against the auxiliary plant. This becomes more and more important as condensing conditions become more unfavorable.

It is important to deliver steam to the turbine as dry as possible, owing to the well known effect of moisture in decreasing the output through friction. The quality of steam from the engines is, of course, indeterminate, but varies between wide limits, averaging 93 to 90 per cent., or less. So that a separator had best be installed in the exhaust main before the turbine. This also serves to remove the water of condensation from a long run of exhaust piping. This necessity suggests the use of a moderate superheat in the engine, sufficient to insure dry steam at the turbine, entirely feasible with the internal type of superheater in common use. This would avoid the resistance through the separator, which may be a serious matter in dealing with large piping and high velocities. The only other alternative is the use of drying coils in the exhaust main. This, however, has proved to be decidedly uneconomical if live steam must be used for this purpose. It could be applied only in cases where some form of waste heat could be used to advantage.

Summary

The most important thoughts presented in the preceding may be summarized as follows:

(1) Low-pressure turbine application is exceedingly flexible, and may work into existing engine plants of good, as well as poor, design to advantage, in conjunction with engines of high- as well as low-expansion ratio.

(2) Regenerative accumulators not always essential in low-pressure turbine work; in fact, average power-plant work does not require their use, resulting in great simplification of plant.

(3) Important to choose proper turbine size so as to permit good economy in engine and maintain exhaust pressures above atmosphere during normal loading, thus preventing air leakage in valves and piping.

(4) During periods of light loads, it may be expedient to run engine condensing, omitting the turbine entirely.

(5) For infrequent or long-continued deficiencies in the steam supply, the turbine may take live steam through a reducing valve to supplement normal supply.

(6) Inherent efficiency of both turbine and combined plant greatest at moderate vacua, 70 to 73 per cent. of the ideal steam cycle.

(7) Condenser problem lies largely in its ability to work on small temperature differences.

(8) Weight and cost of low-pressure turbine unit not far from that of the complete expansion unit. Length of turbine reduced about 30 per cent., unit about 18 per cent.

(9) No governor required if turbine is electrically connected to engine and takes all or part of the steam.

(10) Efficient safety overspeed stop a vital necessity.

Surface Condensers

By Frederick L. Ray

The type of condenser shown in Fig. 1 is practically a salt-water apparatus, as this is the only type that salt water can be used with where it is desired to use the condensation for boiler-feed water; and even with this type it is often impracticable to use the condensation because of leaky tubes allowing the salt water to mix with the water of condensation. If it were possible always to keep the condenser tubes tight, then the surface condenser could be used on the sea coast and salt water used for cooling purposes.

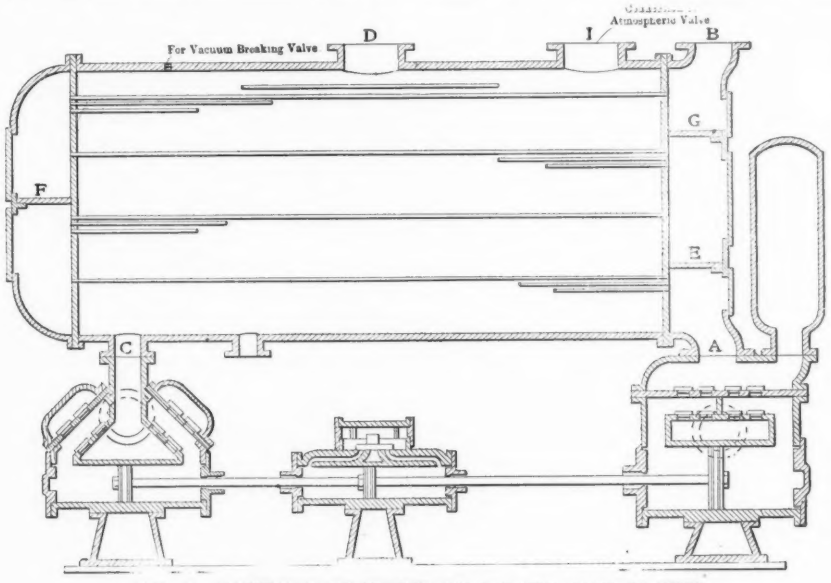


FIG. 1. CONDENSER IN WHICH SALT WATER MAY BE USED

Where the circulating water is also used for boiler feed, the surface condenser may be used regardless of leaky tubes. But why go to the extra cost for equipment for such a large cooling surface, circulating and air pumps, where the jet condenser would answer as well and often much better? The surface condenser requires much more attention on the part of the operating engineer, is more complicated and costs much more than the jet condenser.

Care and Operation

As there are many surface condensers in use and more will be installed, regardless of trouble and costly repairs, a few observations on their care and operation are given in the following:

Fig. 1 shows a sectional view of a surface condenser and pumps on one base, in which *A* is the inlet for the circulating water, *B* the discharge for it, and *D* the inlet for exhaust steam which, on entering, strikes a perforated plate, and is distributed over the tubes, thus protecting the tubes from the impact of the steam.

The instant the steam strikes the cold surface of the tubes it is condensed and falls to the bottom of the condensing chamber, from which it flows out at the nozzle *C* to the air pump. The circulating water passes in at *A* and out at *B*, and in its course meets the baffle plate *E F G*, which causes it to pass through the condensers four times. It would appear that this construction would require only one-fourth as much as if the water passed through but once, but this cannot be, as in the repeated passing through the tube, in contact with the steam, it is heated, becomes less efficient and more is required in consequence.

This construction requires that the condenser be somewhat larger, due to the less efficient cooling surface of the tube, but at the same time requires a very much smaller circulating pump. At the left is shown the connection to a vacuum-breaking valve, used to destroy the vacuum before shutting down the air pump, and an automatic atmosphere snifting valve is connected to the outlet *I*. Should the air or the circulating pump break down, or the vacuum be destroyed from any cause while the engine is in operation, this valve will open and relieve the condenser of any excess pressure, and the engine can be run noncondensing.

The tubes of this type of condenser, being quite small, are easily stopped up and considerable trouble may arise from this source, especially when sea water is used, as it always carries more or less seaweed. A strainer of fine mesh is sometimes inserted between the foot valve and the pump, in which case the pump is protected as well as the condenser. This strainer requires cleaning often to insure a proper supply of water.

After a time the steam side of the tubes of a condenser becomes coated with grease carried over with the exhaust steam, and when thickly coated the efficiency of the condenser is greatly impaired, as grease is a nonconductor of heat.

Boiling Out

A process called "boiling out" is effective when animal or vegetable oils are used and is accomplished by fitting the condenser with a soda cock, so that caustic soda can be injected into the steam space upon the grease-covered tubes. The alkali coming in contact with the grease changes it into soap, and in this condition it is easily washed out through the drain cock. This operation is as follows: The steam side of the condenser is filled with water up to and covering the top row of tubes, the alkali is introduced and live steam is let into the condenser, discharging into the water until the water boils. The amount of alkali to be used will need to be determined by experiment, but in any case enough must be used to make the water strongly alkali.

Animal and vegetable oils have been practically superseded by mineral oils for use in the steam cylinder except as they are compounded with mineral oils. Caustic soda has no effect on the grease deposited from mineral oils, therefore the boiling-out process cannot be used. There is no other way but to clean them by hand and to do this the tubes must be removed. It is a difficult and disagreeable task to clean a large surface condenser, as the grease is heavy and sticky, resembling tar. If possible, the grease should be kept out of a condenser and this can be accomplished by installing a grease extractor between the engines and condenser. It should be installed as a matter of economy, making the condenser more efficient and reducing the cost of cleaning and repairs.

Condenser Tubes

Condenser tubes are subjected to great

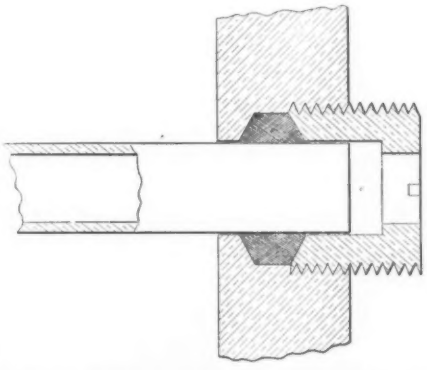


FIG. 2. SPECIAL TUBE END CONSTRUCTION

extremes of expansion and contraction. In Fig. 2 is shown a method of construction which allows the tube end movement and yet will not allow the tube to crawl out of the packing. This is done by counterboring the screw gland that screws down on the packing which consists of cotton lamp wicking, cotton tape or a rubber ring.

The sources of water leaks in a surface condenser consist of split tubes and defective packing at the tube ends. To test for this leakage, remove the cover plate on the end of the condenser and then, by filling the steam space with water, any leaks will be indicated and should be marked for repairs. If temporary repairs must be made, white-pine plugs can be driven into each end of the tube where the tube is split and any packing that is leaking should be replaced with new.

Air leaks will be indicated by a falling vacuum, other conditions being normal, and will be found at the packing on the exhaust-valve stems and piston rods, although it may be at many other places. A lighted candle held to the joint is the best test and when there is a leak the flame will be drawn inwardly. On joints where the tightening of the bolts will not remedy the trouble, the leak may be stopped by plastering over with putty or by driving in hardwood wedges.

When the condensation is returned to the boiler it is very important that the temperature be as high as it is possible to get it, therefore the condenser should be fitted with a thermometer. Under the best conditions it is possible to secure only a certain degree of vacuum, and when more water is circulated than necessary to secure the best vacuum, there is a waste from two directions, i.e., the temperature of feed water is lowered and the circulating pump is using more steam than necessary. Just enough circulating water should be pumped to give the required vacuum, and this will give the highest attainable temperature to the feed water. A reliable thermometer will help the careful engineer to save tons of coal.

Operation of Induced Draft and Suction Producers

By Frank P. Peterson

It is in the nature of the gas producer, possibly in a wider ratio with reference to plant or unit size than with the steam boiler, that the liability to serious accident increases with the extent of the plant. In the very small producer it may be truly said that there is practically no danger, and no liability to serious destruction of the apparatus from explosions which may occur within its parts. This is not due to any difference whatever in the character or inflammability of the gas, but rather to the relative physical strength of vessels containing gas.

Without exception, we may assume that trained engineers possess a sufficient knowledge, if they only stop and think, to avoid the intermixture of air and gas where the mixture is at all likely to become ignited. The greater the volume of such a mixture, the greater becomes the danger from its ignition and the wreckage it can produce.

There come, sometimes, trying times in the operation of large boiler installations for which no particular person or preventable circumstance may be held responsible. Invariably we expect boiler attendants to watch for and anticipate these critical conditions, with readiness to do the right thing at the right moment. So there come, also, trying times in the operation of gas-generating apparatus of whatever character, and just as with the boiler, the seriousness of the circumstances may be such that a cool head may be the only means of salvation.

Danger of Explosion

The one primary idea to be borne in mind by the operator of any gas-generating apparatus is that whenever and wherever air is admitted into a volume of gas, danger of explosion exists. To illustrate how this point is guarded and feared in the handling of large volumes of richer gases, let me recall an incident of which I was a witness in a large gas works. A single exhauster, direct driven by a steam engine, handled the gas generated by a battery of thirty retort coke ovens of the Solvay type—possibly 130,000 cubic feet per hour. This exhauster delivered a portion of the washed gas back to the burners that heated the system of ovens and through an 8-inch main pipe. The remainder of the gas was delivered into a system of pipes that supplied steel furnaces. On the vacuum side of the exhauster (between it and the ovens) were arranged in series four condensing chambers having a combined volume capacity of probably 7000 cubic feet.

The first warning that something had gone wrong came in the form of an explosion in the 8-inch gas main delivering to the oven burners. The blanked end of this main and a tee at that point were disrupted and blown away. Immediately following this came a series of explosions resembling heavy cannon discharges, occurring at intervals of a few seconds and continuing, it seemed to me, several minutes. The last water seal between the exhauster and the ovens was located near the ovens. Each ignition of the gas burned all that had accumulated since the last explosion back to this seal, and an automatic rapid-fire artillery performance was set up as long as the exhauster continued to deliver an explosive mixture.

Now, you say, why didn't they shut down the exhauster?

With the first report every man sought his post, of course, and the shutting down of the exhauster was the first move the operating engineer would have made, with the permission of the man in charge, but the man in charge had other ideas. There is no doubt that he was doing some rapid-fire thinking, and there were other considerations than the mere stopping of a noise after the one small damage had been done.

The source of trouble would be much more readily located with the exhauster in motion, to say nothing of the serious liability of the combustion to reach backward through broken seals with the lessening of pressures in front and of vacuum behind the exhauster; and, furthermore, depending upon the location of this leakage of air into the system might have been the demolishment of the whole condensing system.

While the shutting down of an exhauster without due warning to everybody concerned meant serious delay and damage to operation, obviously this thing must end somewhere, and the man on whom the burden rested was thinking and acting in sharp blue streaks, though it may take a long time to tell the story. The exhauster was shut down in the end, and no direct cause was located in actual evidence for the derangement, yet there was no mystery about it. Either a seal had been broken admitting air, or one of the operatives had made and corrected an error—taken off and had replaced a cap or plug in one of the many inspection openings.

This incident only serves to show how exciting a situation may become, and how essential to safety and a minimum of property loss is a cool head in the handling of the richer gases, and yet there do not arise any such emergencies that may not be paralleled in frequency and gravity by serious boiler-plant situations. Indeed, in the same plant I can recall that our most frequent and serious anxieties were for our boilers, which were heated by the spent gases from the oven-heating systems. The water supply was not reliable at all times, nor were the dampers controlling or shunting the flue gases, and since the temperatures were high and steam plentiful this became a rather serious combination.

What a Careless Attendant Did

Another incident in producer operation: The attendant had prepared a suction producer for starting up. The producer was of 300 horsepower capacity and the space beneath the grates was of considerable volume, possibly 40 or 50 cubic feet. He had blasted the bed of new fuel to the point of making good producer gas and everything was in prime condition for a prompt start on the engine operator's signal for gas. The two men, working together, understood each other perfectly and all the conditions and liabilities that were involved, but the producer attendant had become a little careless. So, when the signal was given from the engine room, he shut off the blower, threw over the three-way valve and folded his arms, anticipating an immediate start of the engine. After a dozen seconds this start had not been made. Now a dozen seconds at a time like this are sufficient to make a gas-producer operator thoughtful, and the attendant suddenly remembered that his ash doors were all clamped up tightly, and that if just a few more seconds elapsed before the starting of the engine, there would be trouble. Not serious trouble, the producer not destroyed, nobody killed, but probably a door-bar snapped or a producer lining loosened up.

Of course, the first thought would be to open a door *quickly*, but self-preservation being the first law, etc., a cool-headed operator will never attempt to open a door at a time like this. If the engine should start just at the time of laying hold of this door, it may mean, at the worst, a broken arm or leg, and the sensible thing to do is to leave the producer alone and find out what may be wrong at the other end.

The engine man had thought he was all ready to start, but an auxiliary cam would not shift, or a battery switch had been forgotten, or even worse, as a result of which it might be three or four minutes more yet. What then? Go back and open the ash doors and let the producer stand in communication with the engine until ready to start? If the producer is in a room communicating with others where the polluted atmosphere may reach a sensitive constitution, no.

Supposing the producer to be in a fireproof room of only the needed dimensions, let us assume the extreme possibility. This room might become pretty well filled with gas in a few minutes, and when the engine starts up, not only the producer may sustain a shock, but the whole room as well. This last has not occurred, to the writer's knowledge, but a cool head and a careful man will take even such remote contingencies as this into consideration, and act accordingly.

Well, what would be the right thing to do at such a moment, throw back the three-way valve into communication with the purge pipe? Not just yet. *Be sure to open an ash door first; then throw the three-way valve,* because an ignition of the gas below the grates will occur three times out of five under such circumstances, and the one always safe and sure thing to do is to unfasten, or partially open, a base door *just before the blower is stopped.*

And why will these base explosions occur? Why, simply because when the three-way valve is thrown into engine position, the only exit for the gas distilled from the hot fuel is backward, beneath the grate and through the draft conduit. Live fire is resting on the grate bars, and when the engine starts, or the reversal of the three-way valve gives the less active draft by the vent pipe, air is drawn in, partly displacing the gas beneath the grates. When sufficient gas has been displaced by air the remaining mixture ignites from the live fire through which it cannot avoid passing. This contingency is not provided for by the producer builders, because it is not considered sufficiently serious as a danger; nevertheless, a careful attendant will always avoid it.

Flame Arresters Desirable for Test Cocks

In large producers test cocks that are to be lighted, when located anywhere else than on the fuel chambers, should be provided in all cases with gauze flame arresters. In this connection, it is the writer's contention that every operator of a gas producer should have the common judgment, or the training, to enable him to operate his plant right along without resorting to test flames at any point other than on his fuel chamber or vent pipe. This is the one safe means of handling producers without incurring the dangers due to this practice.

When a plant is once put in service and is reasonably free from leakage, the gas left in the vessels at shutting down is better than any new gas which may be made to displace it, so why not start up on it? Here, too, there is one precaution to be taken. New coke fillings in gas scrubbers will absorb considerable volumes of the gas, and if this absorption takes place during a considerable period of layover, even though the engine may have been operated for a short time, and if there is even a small leakage, a considerable volume of air will be drawn in, and there is danger in the application of a test flame. An operator, knowing this, will take no chances, but will blow over a new supply of gas to his engine for the first few times starting up. But he will not need to apply a test flame at the engine. He will have someone to turn his blower for him, if it be a small plant, for these first few starts, and he will know from what he has been told, or from common horse sense, how long will be required to pass this new supply of gas over to the engine. It is evident that the liability to ignition of an explosive mixture is less through the inlet-valve port of an engine normally operating or starting than by the application of a flame to an open jet. The writer has in mind one plant which has been in operation for more than a year. No test flame has ever been applied at the engine; there is no provision for it, and none is sought, the attendant having been instructed to get along without such means.

An incident is recalled of a suction generator of some 200 horsepower capacity under starting blast in which from one poke hole inflammable gas was issuing, while from a poke hole on the opposite side of the fuel bed apparently pure air issued. This is a rare occurrence, of course, but in no way unaccountable. An old bed, after some days' layover, is not as thoroughly cleaned as it should be, because to do so involves the loss of all the fire, and to start a new fire outright takes longer then to blast in the old fire that remains. One side of the bed contains a mass of old clinker which is to be removed as soon as the conditions will permit. It seems quite likely that an improper handling or understanding of this extreme case might cause an explosion.

Finally, a little diligence on the part of the plant operator to acquaint himself with the few simple laws that make for the safety of operation will be worth much, as well as all the talk he can absorb, yet it is unfair to expect him to get all the little details of precaution instilled into his methods by running the liability to danger that so many writers and authorities allow to go undissected in their discussions. He will soon learn, in practice, that in the operation of suction and induced-draft producers the admission of a small volume of air into the system between the producer fire and the source of draft is not a serious matter, and no chance or risk at all is sustained. But this volume must be small relative to the volume of gas passing, else serious hindrance, at least, may occur. Therein lies justification for advising the use of a tamping bar with a nob on the end quite sparingly in the operation of a small suction producer.

A 1-inch opening in the top of the fuel chamber of a 350-horsepower producer running with a ⅜-inch (water) vacuum will do no damage; it will scarcely be appreciable for the length of time required to bar that portion of the fire, or inspect the bed. But the same opening into a 10-horsepower producer fuel chamber working at the same rate is almost sufficient to cause an explosion, and, if ignited, will at least shut down the engine being supplied.

We are arriving at the intensely practical stage of producer work which demands attention to details, and in our haste to see results, we are and have been too prone to neglect some of these details that are important.

Improved Pressure Oiling System

By William Kavanagh

The improved pressure oiling system herein illustrated and described will be found a very handy equipment in the dynamo plant, office building, hotel, or factory engine room. It can be constructed and erected at a very moderate cost and will be found highly economical in the use of oil, as all of the waste oil can be returned, filtered and used again, as long as the oil contains lubricating qualities. In a plant where numerous units are to be oiled and an oil-return and filtering system is not in operation, considerable oil is lost, thus adding to the expenses of operation; but where a plant is equipped with a system such as described in this article, the oiling expense should be reduced nearly 50 per cent., not to mention the saving of the labor necessary to do the oiling by hand.

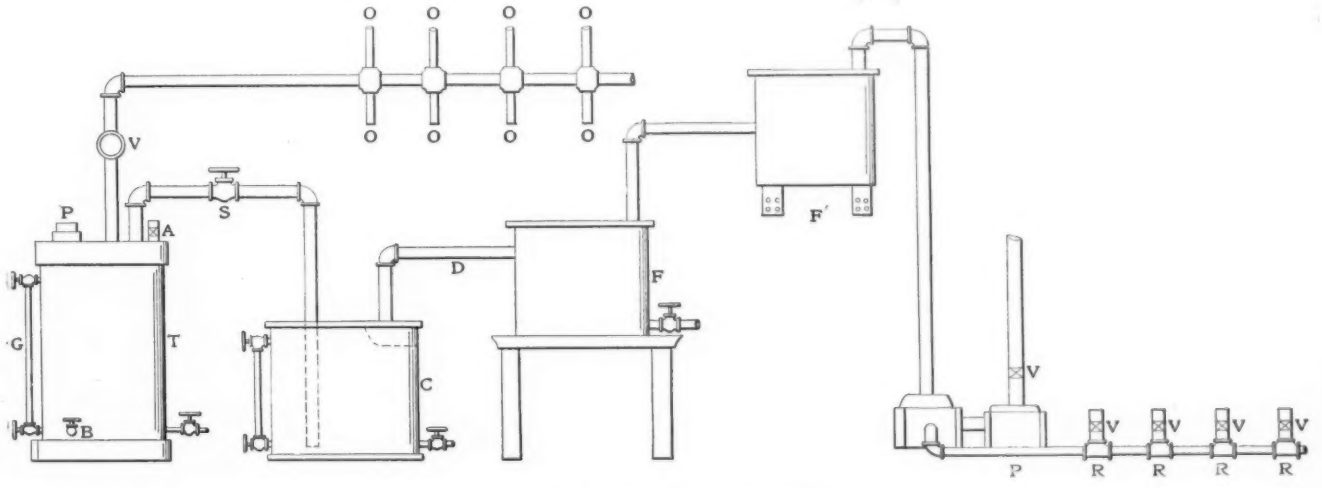


FIG. 1. LAYOUT OF OILING SYSTEM

The system under consideration may be homemade, if necessary, with the exception of the fittings, pipe and oil-return pump. The filters and receiving tank may be made from oil barrels, while the pressure tank may be constructed of galvanized sheet iron, or common iron pipe. The outfit will be found so economical, however, that it will be a good investment to have the equipment properly constructed and arranged to handle all of the returned oil from the various units.

Fig. 1 illustrates the entire system. The oil-return pump *P* draws the waste oil from the different units through the oil-return pipes *R R R R* and then discharges the waste oil into the screen, or rough filter *F'*, where the water is rapidly eliminated from the oil. The oil will flow from *F'* into the main filter *F*, then through the pipe *D* into the receiving tank *C*, where it remains until needed for use. The oil is taken from the receiving or storage tank *C* either by a pump or water siphon and discharged into the

pressure tank *T*, from whence it is fed to the various units, under a pressure equal to that of the water, if water is used, or, if a pump is used, under any desired pressure which can be maintained on the oil in the tank *T*. The oil flows from *T* through the various outlets shown at *O*, which connect with the oil cups or bearings of the dynamos, engines, or whatever bearing is to be lubricated, the amount of oil flowing into each cup or bearing being controlled by means of a valve placed conveniently over each bearing or cup. In the drawings the location of the valves is indicated by *V*.

The size of pipe to employ in erecting this system will depend on the amount of oil required for each bearing. The main or trunk lines may be any required size from ⅜ inch upward, but the branch

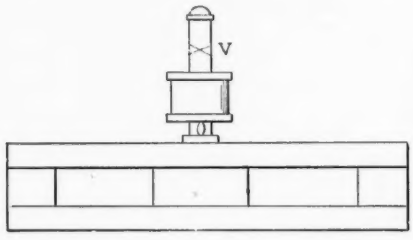


FIG. 2

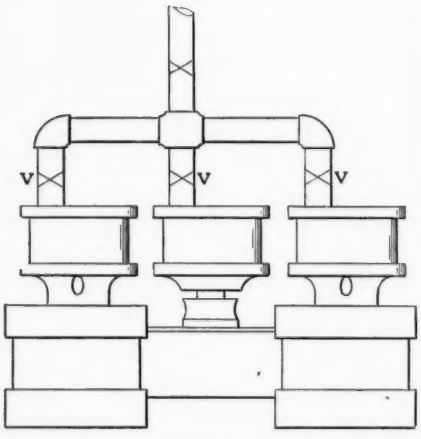


FIG. 3

lines leading into the bearings or cups may be ⅛ inch, and if made of brass will present a neat appearance.

Fig. 2 shows how the pipe carrying oil is attached to the crosshead-slide oil cup, and Fig. 3 is an end view of Fig. 2 and shows plainly the piping for slides and crosshead wipers. Fig. 4 shows oiling connections for main bearings and the crank-pin wiper; Fig. 5 illustrates a sectional view of the "dry" filter, and Fig. 6 is a sectional view of the "wet," or water filter, either of which may be used in this system of oiling. If the pressure on this system is maintained by means of water, the tank *T* should be large enough to contain sufficient oil for a continuous run of, say, from 36 to 60 hours; but if a pump is used to maintain the pressure, the tank *T* need not be so large because the oil supply can be constantly maintained.

The pressure to operate this system will depend in a great measure on the distance it is located from the engine room and the number of bends through which the oil must flow. In actual practice 30 pounds pressure is found sufficient to do the work at this plant, although the system is located more than 50 feet from the engine room.

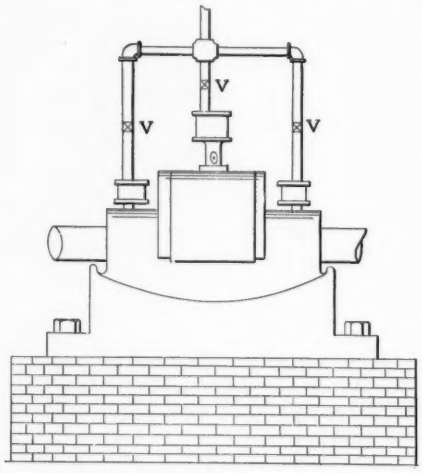


FIG. 4

To operate the system with water, assuming that there is no oil in *T*, fill *T* with water and when water appears at the air vent at *A* shut the water off and close *A*. Open valve *B* and allow the water to run off to the sewer, then open valve *S*, which connects the oil supply in tank *C* with the pressure tank *T*; the oil will be siphoned into *T*, and as the water lowers or runs off, oil will take its place and the amount of oil which has flown into *T* will be indicated by the gage glass *G*. When sufficient oil is in *T*, shut *S* and *B* and open the water valve, and whatever pressure is exerted by the water will be impressed on the lower surface of the oil and tend to force the oil out through the valve *V*. By opening *V*, the oil will flow out through the main line and connections, as indicated at *O*.

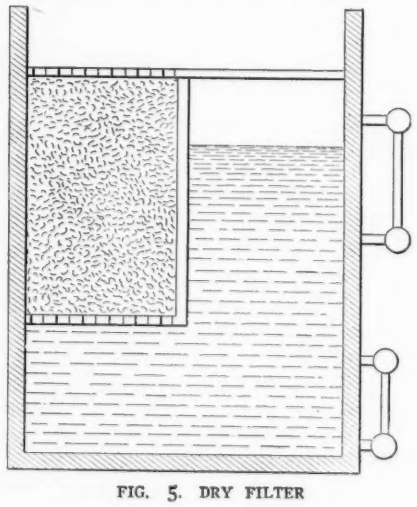


FIG. 5. DRY FILTER

To stop the system from feeding oil shut *V* and the water valve and allow the oil-return pump to run until all of the waste oil is pumped back into *F'*. After shutting down this oiling system it will not be necessary to disturb the setting of the valves located above the oil cups; therefore, on restarting the system adjustment of those valves will not be necessary. By doing this considerable time and labor are saved in starting up. Occasionally the tank *T* should be cleaned out. After allowing all of the oil to flow out of *T*, open the washing-out plug *P* and the valve *B* and allow all of the dirty water and sediment to flow off to the sewer; by playing a strong stream of water through *P* it will facilitate matters considerably.

In fitting up the system it is a good plan to have the oil pipes enter the top of the cups loosely and connected to one side of each cup, as shown in the drawings, as this permits of lifting out the pipes from the cups and of hand oiling,

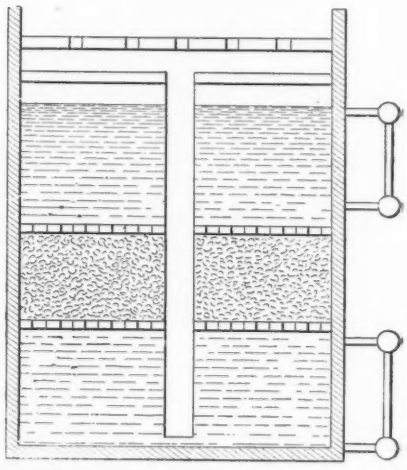


FIG. 6. WET FILTER

should anything occur to prevent the system from operating. Also, the oil cups may be cleaned or new glasses inserted without having to unscrew the piping.

Protection of Underground Pipes

C. H. Staten spoke before the Modern Science Club, of Brooklyn, N. Y., Tuesday evening, December 22, on "Insulating and Protecting Underground Steam and Hot Water Pipes." He dwelt at length on the history of the development of central-station heating plants and traced the poor results and failures, which marked the earlier ventures in this direction, to lack of proper protection and insulation.

With a system designed in accord with the best practice of the present time, Mr. Staten said, heating could be done from central stations at a cost not exceeding 30 cents per square foot of radiating surface for seven months.

The Compression Refrigerating System

By F. E. Matthews

What are the general functions of a refrigerating system as a whole and of its different parts? Why does the back pressure rise when the machine is shut down? What is "frosting back"? Is it a waste?

The function of a refrigerating means, whether it be an absorption or a compression refrigerating machine, or simply a bunker full of ice, is to provide a heat-absorbing medium which, after it has absorbed its fill of heat from the products that it is desired to cool in the cold-storage rooms, or other places to be refrigerated (which for simplicity we will hereafter call coolers), may be removed from such coolers so that the heat absorbed may also be removed. After its removal from the "coolers" this medium may either be divested of its heat, after which it may be again returned to the coolers and allowed to absorb more heat, as in the case of ammonia or brine circulated through coolers, or it may be thrown away and a new supply introduced, as in the case of cooling by ice.

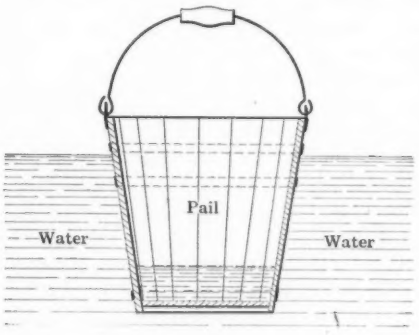
A pound of liquid ammonia in evaporating at 0 degree Fahrenheit has a heat-absorbing capacity of 555.5 British thermal units (B.t.u.) of heat, a B.t.u. being the amount of heat required to raise the temperature of a pound of water 1 degree Fahrenheit. Vapors of ammonia are easily liquefiable, so that in consideration of its high commercial value it becomes economy to use this medium over and over again.

A pound of ice in melting has a heat-absorbing capacity of 144 B.t.u. While the water from the melting ice might readily be frozen again by mechanical means and might accordingly be used over and over again, as is the case with ammonia, its low commercial value when coupled with the fact that it can often be obtained already in the naturally frozen state, to say nothing of such factors as contamination by products in the coolers and transportation to a place where it might be frozen, makes it eminently impracticable even to consider using this medium but once.

An apt though rather old illustration of the action of a refrigerating machine, or in fact any heat-absorbing means, is that of the absorption of water by a sponge. The tendency of the sponge to absorb water after one charge has been squeezed out of it is not altogether unlike that of anhydrous ammonia and other liquefiable refrigerating media to absorb heat after the former charge has been squeezed out. The two media, water and heat, may both be considered passive, and simply acting under the influence of the sponge and the refrigerating medium.

A containing vessel, such as a more or less leaky pail, partially sunk in a body of water, as roughly indicated in the accompanying sketch, may be shown to be similar to a cold-storage compartment surrounded by an atmosphere higher in temperature than that within. Since the level of the water in the pail is lower than that on the outside, and since the pail is more or less leaky, a certain amount of water will leak into the pail from the outside. If none of the water is removed or if the process of removal proceeds less rapidly than the infiltration, the pail will eventually fill up to the level of the water on the outside.

Carrying out the comparison in the case of a cooler, the higher temperature on the outside tends to cause an infiltration of heat through the more or less leaky cooler walls. If no steps are taken to remove this heat or if the means adopted be inadequate, the temperature within the cooler will eventually rise to that of the surrounding air. The nearer full the pail is, that is, the less the difference in level and pressure between the water on the inside and the outside of



ILLUSTRATING A COLD-STORAGE PRINCIPLE

the pail, the less will be the water leakage. The warmer the air in the cooler, that is, the less the difference in temperature between the atmosphere on the inside and outside of the cooler the less will be the heat leakage. Furthermore, in the process of "bailing out," the lower the water level in the pail, making it necessary to lift it through a greater distance, the more work will be required. Similarly, the lower the temperature in the cooler the more energy must be expended to expel the heat on account of the increased range of temperature through which it must be raised.

In brief, a compression refrigerating machine consists of the necessary mechanical means of circulating a heat-absorbing medium through the cooler and of removing from this medium the heat which it absorbs *en route*. The heat absorbed in the cooler passes from the atmosphere, products, etc., by virtue of the fact that the refrigerating medium is lower in temperature. This same heat must be similarly removed from the refrigerating medium by introducing a secondary cooling medium materially lower in temperature. Since there is no secondary cooling medium of a lower temperature available than the refrigerating medium, even at the temperature at which it returns from the cooler after having absorbed larger quantities of heat, it becomes necessary to raise the temperature of the refrigerating medium enough so that it can be cooled. This is effected in the case of the absorption system by the direct application of heat in the "generator" and in the compression system by the performance of work in a suitable form of "compressor."

Carrying out the comparison of the sponge and the water in the pail, it is evident that the water after being absorbed by the sponge must be raised to a higher level before it can be made to flow away to the surrounding water at the higher level.

More specifically, a compression refrigerating system consists of a set of pipes, or other containing vessel, in the cooler in which the refrigerating medium absorbs heat at a low temperature from the products to be refrigerated and a second set of pipes, or other containing vessel, outside of the cooler in which the refrigerating medium gives up its heat to a secondary cooling medium, such as water or air at a comparatively high temperature, and a compressor for raising the temperature of the refrigerating medium sufficiently to enable it to give up its heat to the secondary cooling medium.

In the operation of such a system almost any gaseous working medium might be employed. In practice, however, the list is limited to only such gases as are capable of being liquefied under ordinary natural temperatures and not too high mechanically produced pressures. Judging from the relative number of commercial installations employing the different media one may assume that under the average conditions anhydrous ammonia comes more nearly to fulfilling all of the requirements of an ideal working medium than any other. This medium will be considered throughout the remainder of this article.

The pipes, located in the cooler, through the walls of which the ammonia absorbs heat from the objects to be refrigerated are erroneously called "expansion" coils, and those located outside the cooler through the walls of which the ammonia gives up its heat, condenser coils. The ammonia previously liquefied in the condenser under a pressure of from 135 to 200 pounds, according to the temperature of the cooling water, is conveyed first to the "receiver," which consists of an appropriate cylindrical containing vessel which acts as a storage tank in which the liquefied ammonia is collected and from which it passes as required into the expansion coils. The flow of this high-pressure liquid into the expansion coils is regulated by "expansion" valves, which are virtually nothing more than convenient

mechanical devices for accurately varying the opening through which the liquid ammonia must pass on its way to the expansion coils. As stated, the word "expansion" has been erroneously applied to these coils and valves because of the idea, likewise erroneous, that the liquid ammonia vaporizes or "expands" immediately the pressure is relieved, as it passes the regulating valve and enters the cooling coils. As a matter of fact, before it is possible for a pound of ammonia to change from the liquid to the gaseous state it must be supplied with about 555.5 B.t.u. of heat.* If this amount of heat were absorbed at the expansion valve, which its immediate vaporization assumes, there would be no further heat-absorbing capacity in the ammonia, and its introduction into the "expansion" coils would be useless.

In the expansion coils the liquid ammonia, which has the peculiar property of boiling at a very low temperature, 28.5 degrees below Fahrenheit zero under atmospheric pressure, absorbs heat from the surrounding atmosphere, boils and vaporizes in much the same way as water, absorbs heat from the hot furnace gases, boils and vaporizes in the similarly constructed pipe coils of an ordinary water-tube boiler.

Having evaporated to a dry gas, the ammonia vapor leaves the expansion coils and enters a "return" header which conveys it back to the suction side of the compressor. This return line is usually fitted with a "scale trap" constructed quite similarly to some of the more simple types of steam separator. The function of this trap is to prevent any scale from the inside of the pipes, or other foreign substances, from entering and damaging the compressor.

It often happens that the expansion valves are not properly adjusted, or that the expansion coils are so arranged that, like poorly designed boilers, there is an abnormal entrainment and considerable liquid ammonia is carried back with the returning vapor. In this case the scale separator may act as a veritable separator and temporarily interrupt the passage of the entrained liquid ammonia to the machine. On account of the difficulty of returning any liquid so trapped to the expansion coils the scale traps are of little value as separators except as means of keeping occasional large volumes of liquid from returning to the compressor. Once having become filled with liquid ammonia they remain in this condition for some time. Since in order to evaporate, the ammonia must have heat, and since the temperature of the boiling ammonia corresponding to the back pressure usually carried in refrigerating and ice-making work is sufficiently low to produce ice on the outside of the traps, piping, etc., these parts soon become heavily insulated with ice which further materially reduces the amount of heat that can be absorbed, and the entrained liquid enters the compressor with considerable capacity for absorbing heat. If this amount is abnormal it may cause the compressor to pound for the same obvious reason that a steam engine pounds when it receives a quantity of entrained water in the steam. When quantities of liquid ammonia sufficient to cause the compressor to pound enter the compressor cylinder, it is usually evidenced by the abnormal cooling effect on the compressor walls, or more noticeably that of the piston rods which, through their contraction, as well as that of the packing and stuffing boxes, may even allow the ammonia to leak by the packing. The evaporation of this entrained liquid ammonia in the compressor cylinder, or that introduced directly into the cylinder through an expansion valve designed for that purpose, refrigerates the gas as well as the compressor parts and tends to prevent superheating of the gas during compression. The evaporation of the liquid ammonia remaining in the expansion coils when the compressor is shut down causes the rise in back pressure usually so noticeable a few hours after the plant has been shut down.

The condition of the ammonia vapor as regards saturation or supersaturation may best be arrived at through thermometers inserted in mercury wells in the return and discharge lines near the compressor. Tables of "properties of saturated ammonia" indicate at a glance the temperatures at which the vapors should return to the machine under different conditions of back pressure and assumed saturation.

If the last trace of the liquid ammonia is evaporated before the vapors reach the compressor, and the return pipes are uninsulated, there is likely to be considerable superheating, i.e., the temperature of the vapor entering the compressor is likely to be several degrees higher than that shown by the tables to correspond to the back pressure carried. This condition results in a considerable loss of efficiency and should not be allowed to continue.

While difference in opinion regarding the amount of unevaporated liquid the return ammonia gas should contain in order to give maximum efficiency has given rise to two distinct systems, viz., the "wet" and the "dry" compression, a discussion of the relative merits of the two systems would be too far-reaching to warrant its introduction here. The best general rule regarding the wet or dry operation of compressors is to follow the instructions of the respective builders as closely as possible.

In the absence of more accurate means, such as thermometers, for determining the temperature of the returning ammonia gas, the "frost line" has been forced into service to give at least some slight indication of such temperatures. The simple formation of frost on the outside of a pipe containing cold ammonia gas, or, in fact, any other cold medium, indicates nothing more nor less than that the heat from the outside atmosphere is absorbed with sufficient rapidity to reduce the temperature of the pipe and nearby air to at least 32 degrees Fahrenheit, under which condition atmospheric moisture is, first, precipitated, just as rain or dew is formed when moisture-ladened air becomes cooled by heat radiation to air at a lower temperature or contact with other colder objects and, second, is frozen, just as dew is frozen to form frost when its temperature is reduced to 32 degrees Fahrenheit.

Since the formation of frost on an ammonia pipe is influenced by the room temperature, it cannot be an ideal means of judging temperature. Where considerable entrained liquid ammonia is present to evaporate and absorb heat rapidly, the general appearance of the frost formed, or the way one's wet finger sticks to the pipe, may give some slight indication of the action taking place inside. Where low temperatures are carried the return gas may be so far below 32 degrees Fahrenheit that the same rise in temperature that would ordinarily completely change the appearance of the return line if it took place at a higher temperature would not affect the frosted line at all, as far as outward appearances are concerned.

It may be generally asserted that it costs an expenditure of energy to remove heat from any substance at any temperature to another substance at a higher temperature. If, then, a certain amount of the heat in the returning ammonia gas has its origin in the engine room, where its absorption is manifested by frost in the return line to the compressor, it is evident that the frosting of the line costs energy to drive the compressor and that this energy costs coal, labor and, finally, money. The return lines to compressors should be effectively insulated to reduce this loss. Nothing is more erroneous than the argument that because the returning gas has passed the rooms that it is sent out to cool, there will be no loss by heat absorption through exposed, uncovered cold pipes. The actual cost of producing a B.t.u. of refrigeration can be computed for any refrigerating plant by simply dividing the total operating cost of that plant by the number of B.t.u. of refrigeration produced. The useless expenditure

*In practice not all of the 555.5 B.t.u. of heat-absorbing capacity, or *negative* heat of a pound of anhydrous ammonia available at 0 degrees Fahrenheit can be utilized for useful cooling work. This on account of the cooling work which must first be expended on the ammonia itself in order to reduce its temperature from that of the condenser to that of the cooler. This may be illustrated by a similar process in which water is the medium in question.

The amount of heat that must be abstracted from one pound of water at 32 degrees Fahrenheit, in order to freeze it, is 144 B.t.u. On this basis a ton of ice would represent 288,000 B.t.u. of negative heat. In practice the expenditure of this amount of cooling will not freeze a ton of water because it must first be cooled from its natural temperature or, in crystal-ice systems, from the temperature of the distilling tank down to 32 degrees Fahrenheit. This involves a further expenditure of 1 B.t.u. pound per degree Fahrenheit cooled through.

of a single unit of refrigeration is just as prodigal as the throwing away of an equivalent amount of money. The fact that this and similar losses are allowed to continue in some of the largest refrigerating and ice-making plants in the country is poor excuse for their existence in others.

Catechism of Electricity

888. *How should the motor be wired in circuit?*

In accordance with the diagram of connections accompanying the machine, or if such a diagram is not furnished, in accordance with the general arrangement shown respectively in Figs. 276, 277 and 278 for shunt-, series- and compound-wound motors.

889. *For which direction of rotation is a motor usually arranged when leaving the factory?*

Unless otherwise specified, motors are usually tested and connected for a left-hand direction of rotation; that is, when facing the machine at the commutator end the top of the armature will turn toward the left. An arrow indicating the proper direction of rotation is generally painted on the machine at the commutator end.

890. *What preliminaries should be observed before starting up a motor for the first time?*

Slowly turn the armature over a few times by hand to make sure that it does not rub or bind, and is perfectly free to revolve. See that the machine throughout is free from dirt or foreign matter, and is properly lined up so that the belt runs in the middle of the pulley. Check up the connections of the motor and its starting rheostat with the wiring diagram for this particular case. Fill the bearings with high-grade dynamo oil until the oil gages show that the proper amount of oil has been introduced. Make sure that the

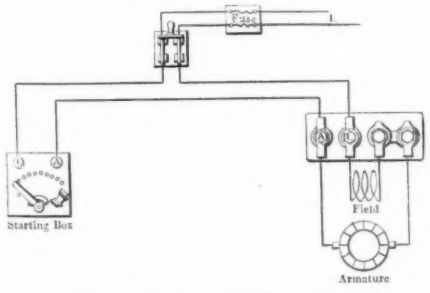


FIG. 277. WIRING DIAGRAM FOR SERIES-WOUND MOTOR AND STARTING RHEOSTAT

oil rings are properly carrying the oil over the bearing surfaces when the armature is turned.

The brushes should be given the proper pressure on the commutator, about 2 pounds per square inch of contact surface. The following table will be found useful in determining the approximate pressure of the brushes on the commutator for various sizes of brushes:

For brushes 1 inch or less wide, about ½ pound.
For brushes 1¼ inches wide, about 1 pound.
For brushes 1½ inches wide, about 1½ pounds.
For brushes 2½ inches wide, about 2½ pounds.
For brushes 2 inches and over, 3 pounds.

891. *How should the pressure of the brushes on the commutator be determined?*

Use an ordinary spring-balance scale *d*, Fig. 278, placing the hook so as to raise the brush *e* perpendicularly to the commutator *a*, and then read on the scale the

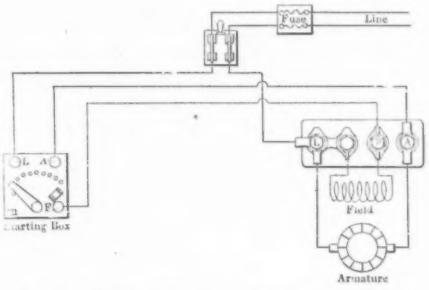


FIG. 276. WIRING DIAGRAM FOR SHUNT-WOUND MOTOR AND STARTING RHEOSTAT

pull in pounds necessary just to lift the brush from the surface of the commutator. If the tension is too great, loosen the thumb screw *s* in the brush holder *c*, which will loosen the spring that presses the brush in position, and if it is too slight, tighten the thumb screw. It is necessary to have the pressure of all the brushes exactly the same.

892. *What directions should be followed in securing the proper position of the brushes on the commutator?*

Motors vary considerably in regard to the position in which their brushes must be placed for the best results. In bipolar motors or motors arranged for rotation in either direction, the position of the brushes should be midway between the pole pieces.

In multipolar machines, a punch mark is generally placed on the rocker arm and two punch marks on the bearing nose. If the motor runs with a left-hand rotation, the punch mark on the rocker should be over the right-hand punch mark on the bearing nose, and with a right-hand rotation over the left-hand punch mark. Reversible motors have only one punch mark on the bearing, the brushes being set centrally, and these motors should run equally well in either direction. A change in the direction of rotation of a motor from right-hand to left-hand rotation is effected by interchanging the main leads and shifting the rocker arm in clockwise direction until the punch mark on the rocker is over the right-hand punch mark on the bearing nose.

893. *If there are no punch marks, how should the brushes be placed?*

The brushes should be placed midway between the centers of the pole faces, allowing for a certain lag previously explained to be necessary, which varies from ⅛ inch to an inch or more, depending upon the size of the motor.

In bipolar machines there are always two studs or sets of brushes and these must be placed exactly 180 degrees apart. In multipolar machines there are usually as many sets of brushes as there are pole pieces. By a series connection or by a cross connection of the armature winding the number of sets of brushes may be reduced to two and these in a four-pole motor should be set 90 degrees apart, in a six-pole motor 60 degrees apart, in an eight-pole motor 45 degrees apart, in a ten-pole motor 36 degrees apart, and in a twelve-pole motor 90 degrees apart.

894. *How should the motor be started for the first time?*

Throw off the belt, close the circuit breaker, if there is one, and then close the main switch, having first made sure that the starting rheostat handle is in the "off" position; then start the motor by moving the rheostat handle to the first contact, hold it there a moment and slowly pass to each successive contact until all resistance is cut out. Give the motor time to speed up before passing from one contact to another.

Allow the motor to run without load for a time to make sure that it is in proper working order. If the machine operates at a speed higher than that on the nameplate, or does not appear to be working properly, turn off the current by opening the main switch. Do not continue to run the motor without locating and remedying the trouble.

When the armature has attained full speed, see that the oil rings revolve properly and that they supply the journals with oil, as otherwise the bearings will run hot. Feel all joints and connections. If any one is warmer than the others, the connection is imperfect and should be tightened.

Care should be taken that the shunt-field circuit of a motor is not opened.

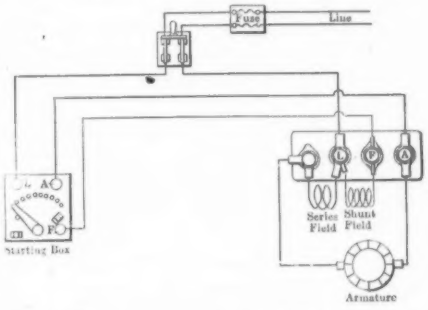


FIG. 278. WIRING DIAGRAM FOR COMPOUND-WOUND MOTOR AND STARTING RHEOSTAT

If this should happen during the operation of the motor the armature will tend to run away if lightly loaded, and flash over if heavily loaded. If the shunt-field circuit is opened when carrying current and the motor is not operating, there is danger of the field coils being punctured. If it becomes necessary to break the field circuit it should be done slowly, allowing the arc formed to die out gradually.

Gas Engine Compression and Efficiency

A Simple Explanation of How and Why the Degree of Compression Affects the Theoretical Efficiency and the Operating Economy

BY PAUL C. PERCY

The statement that the efficiency of a gas or oil engine is increased by increasing the compression pressure of the engine is familiar to all readers who are interested in the subject. The explanation of the statement is probably not so familiar. Put concisely, it is that increasing the compression increases the temperature range of the cycle, and the thermal efficiency depends on the operating temperature range in any form of heat engine.

Just here it may be worth while to remind the reader that a gas engine, like other heat engines, yields several kinds of efficiency, namely, the theoretical cyclic efficiency, the thermodynamic efficiency, thermo-brake efficiency and the mechanical efficiency.

The theoretical cyclic efficiency is the proportion of the heat in the combustible mixture that is available for doing work as it passes through the cylinder. For example, if the charge contains 1000 heat units and 400 of these are discharged in the exhaust gases, the available heat is 1000 — 400 = 600 B.t.u. and the cyclic efficiency is

$$\frac{600}{1000} = 0.6,$$

or 60 per cent.

The thermodynamic efficiency is the proportion of the heat in the gas that is actually utilized in doing work. For example, if the charge contained 1000 heat units and the work per cycle done by the expanding gases on the piston were 233,400 foot-pounds, this would mean that

$$233{,}400 \div 778 = 300$$

heat units had been utilized in doing work, and the thermodynamic efficiency would be

$$\frac{300}{1000} = 0.3,$$

or 30 per cent. If it were possible to operate an engine without losing heat through the cylinder walls and piston, and if complete combustion of the gas were obtained, all of the heat in the gas except that discharged in the exhaust gases would be turned into work and the thermodynamic efficiency would be equal to the cyclic efficiency.

The thermo-brake efficiency is the proportion of heat that is turned into useful work outside the engine and the mechanical efficiency is the ratio of the useful work to the total work done on the piston. For example, if the charge contains 1000 heat units, if the work done on the piston per cycle is 233,400 foot-pounds and if the outside work done by the engine in driving machinery, shafting, etc., is 186,720 foot-pounds per cycle, the thermo-brake efficiency will be

$$\frac{186{,}729 \div 778}{1000} = 0.24$$

or 24 per cent. and the mechanical efficiency will be

$$\frac{186{,}720}{233{,}400} = 0.8,$$

or 80 per cent.

These efficiencies are clearly related to each other, and if one is increased or decreased it will affect one or more of the others. Increasing the cyclic efficiency will increase the thermodynamic efficiency within certain limits, which are different for different engines and different operating conditions. Increasing the thermodynamic efficiency will increase the brake efficiency provided it does not decrease the mechanical efficiency too much by enhancing the friction of the working parts. Increasing the mechanical efficiency will increase the brake efficiency provided the thermodynamic efficiency is not decreased correspondingly, and so on. Now it is the theoretical cyclic efficiency which is directly affected by the compression pressure, and increasing the compression would increase this efficiency indefinitely, as shown by the following analysis:

In the theoretical cycle, in which it is assumed that no heat is lost through the cylinder walls and piston, and that combustion is instantaneous and complete, the temperature rise due to combustion is equal to the heat units in one pound of the cylinder contents divided by the specific heat of the cylinder contents. Now, assume that the cylinder contents weigh one pound, that the admission temperature is T_a degrees, that the compression temperature is T_c degrees, that the explosion temperature is T_x degrees and that the temperature of the exhaust gases is T_e degrees, absolute. The rise of temperature due to combustion will be equal to the heat in the gas (H) divided by the specific heat (C_v) of the cylinder contents at constant volume, thus:

$$T_x - T_c = \frac{H}{C_v}.$$

Consequently, the total heat required to produce a given temperature rise ($T_x - T_c$) will be equal to

$$H = C_v(T_x - T_c).$$

The heat in the exhaust gases is equal to the quantity that would have been required to raise their temperature from that of admission, T_a, to that at which they escape, T_e; this is equal to

$$h = C_v(T_e - T_a).$$

The theoretical cyclic efficiency is equal to

$$\frac{H - h}{H} \text{ or } 1 - \frac{h}{H},$$

and substituting the foregoing equivalents for H and h gives

$$1 - \frac{C_v(T_e - T_a)}{C_v(T_x - T_c)}$$

as the cyclic efficiency expressed in temperatures. The specific heat symbols cancel out, leaving

$$1 - \frac{T_e - T_a}{T_x - T_c} = \textit{cyclic efficiency.}$$

Since both compression and expansion are assumed to be adiabatic in the theoretical cycle, the ratio of explosion temperature to exhaust temperature is the same as the ratio of compression temperature to admission temperature, thus:

$$\frac{T_x}{T_e} = \frac{T_c}{T_a}.$$

Consequently,

$$\frac{T_e - T_a}{T_x - T_c} = \frac{T_a}{T_c},$$

and the formula for theoretical cyclic efficiency may be reduced to

$$1 - \frac{T_a}{T_c} = \textit{cyclic efficiency.}$$

The higher the compression pressure, the higher will be the compression temperature and the smaller will be the fraction

$$\frac{T_a}{T_c};$$

consequently, the higher will be the cyclic efficiency. Take, for example, two engines taking in equal quantities of gas per cycle and at the same temperature, say 700 degrees absolute. Suppose one compresses the cylinder contents from 14 pounds to 61 pounds absolute pressure per square inch; the temperature of compression will

be 983 degrees absolute. Now suppose the temperature rise due to combustion were 1966 degrees; then the explosion temperature would be 1966 + 983 = 2949 degrees absolute. The *theoretical* exhaust temperature would bear the same relation to the explosion temperature that the compression temperature bears to the admission temperature; consequently the theoretical exhaust temperature would be

$$\frac{2949}{983} \times 700 = 2100$$

degrees absolute. The theoretical cyclic efficiency would be

$$1 - \frac{2100 - 700}{2949 - 983} = 0.1879,$$

or 18.79 per cent. The shorter formula gives the same result, thus:

$$1 - \frac{700}{983} = 0.1879.$$

Now suppose the other engine compressed the cylinder contents to 182 pounds absolute pressure per square inch. The compression temperature would be 1457 degrees absolute, and the theoretical cyclic efficiency would be

$$1 - \frac{700}{1457} = 0.48,$$

or 48 per cent., as compared with 18.79 per cent. for the first engine.

Effect on Operating Efficiencies

It does not follow that increasing the compression will always increase the thermodynamic and thermo-brake efficiencies, however. It will do so up to a certain point, but beyond that point any further increase in compression will produce a decrease in operating fuel economy. The point at which this change occurs differs in different engines, and it is not usually the same for both indicated and brake efficiencies. During compression some heat is lost through the cylinder walls and piston, and the higher the compression the greater will be the heat loss. Moreover, higher compression means higher explosion temperature and that increases the heat loss through the walls during combustion and expansion. The loss of heat due to these several causes increases more rapidly than the thermodynamic or indicated efficiency increases; consequently, there is a point at which increasing the compression any further will cause more heat loss than the increase in cyclic efficiency will offset, and the net result will be a decrease in thermodynamic efficiency. Assume, for example, that an engine using natural gas and compressing to 130 pounds absolute shows a thermodynamic efficiency of 30 per cent. The heat taken in per indicated horsepower-hour will be 8483 B.t.u. Now suppose that increasing the compression to 140 pounds would increase the efficiency to 32 per cent. if there were no additional heat losses, but that in fact the heat losses were increased 700 B.t.u. The net result would be that the engine would take in 8653 B.t.u. per indicated horsepower-hour and the thermodynamic efficiency would be reduced from 30 to 29½ per cent. instead of being increased to 32 per cent.

Increasing the compression increases the pressures on the crankpin and main-shaft bearings, and thereby increases the friction and decreases the mechanical efficiency, which tends to offset any increase in indicated efficiency. There are consequently two critical compression pressures, one beyond which the indicated or thermodynamic efficiency begins to decrease by reason of the preponderance of the increase in heat losses and one beyond which the brake efficiency begins to fall off by reason of greater loss due to added friction than gain in indicated efficiency. Usually the latter is lower than the former, though it is possible for the two to coincide.

Influence of Burnt Gases

There is another factor which undoubtedly affects the relation between compression and operating efficiency, although it does not come into the question of theoretical cyclic efficiency. That is the influence of the spent gases in the "clearance" upon the combustion of the fresh charge. It is quite customary to assume that after the expulsion stroke is completed the combustion space or "clearance" remains filled with burnt gases and that the succeeding suction stroke draws in a volume of fresh mixture equal, at the most, to the piston displacement. Except where special means are provided for scavenging, there is no reason to question the accuracy of this assumption. At any rate, it is doubtless true that these conditions are obtained in a large majority of four-stroke gas engines. In such cases, therefore, it is also true that increased compression tends to increased economy by reason of the smaller proportion of dead gases in the cylinder contents at the time of combustion. For example, if the compression ratio of an engine were three, that is, if the cylinder contents were compressed to one-third the volume which they occupied before compression began, the volume of the combustion space would be one-half as great as the volume swept out by the piston; consequently one-third of the cylinder contents would be dead gases and two-thirds fresh mixture. With a compression ratio of six, only one-sixth of the cylinder contents would be dead gases. Consequently, the rise of temperature in the latter case would be one and a quarter times the rise of temperature in the former case, and the area of the theoretical indicator diagram would, therefore, be considerably larger, although the quantity of fuel used would be the same in both cases. Assume, for instance, that the piston displacement in each case is such as to take in 2 cubic feet of fresh mixture, containing 100 B.t.u., that the weight is 0.08 pound and the specific heat at constant volume 0.25 B.t.u. With the compression ratio of three, the total weight of the cylinder contents, including the gases in the combustion space, would be 0.12 pound. The theoretical rise of temperature due to combustion, therefore, would be

$$\frac{100}{0.12 \times 0.25} = 3333$$

degrees Fahrenheit.

With the compression ratio of six, the total weight in the cylinder would be 0.096 pound, and the heat units the same as before. The theoretical rise of temperature, therefore, would be

$$\frac{100}{0.096 \times 0.25} = 4167$$

degrees. Assuming equal combustion efficiency for the two cases, and putting it at 50 per cent., the actual rise of temperature would be 1667 degrees with low compression and 2083 with high compression.

With the lower compression ratio the compression temperature would be about 970 degrees absolute and the pressure about 56 pounds. With the higher ratio, the compression temperature would be about 1190 degrees and the pressure about 136 pounds. Since the relation between compression and explosion pressures is the same as that between compression and explosion temperatures, the following temperatures and pressures would be obtained:

Compression ratio	3	6
Compression pressure	56	136
Compression temperature	970	1190
Explosion temperature	2637	3273
Explosion pressure	152	374
Release temperature	1860	1900
Release pressure	36	37
Mean effective pressure	54	79

The figures for temperatures and pressures are based on an initial temperature of 700 degrees absolute, initial pressure of 13½ pounds absolute, and on 1.3 as the exponent of the compression and expansion curves. In practice, the engine with the higher compression would show better combustion efficiency, because of the more intimate commingling of the molecules of gas and air and the lesser radiating surface of the combustion space, although the latter might be neutralized by the greater average temperature during combustion. However, the figures indicate very clearly and reliably the general effect of high compression upon fuel economy. They also indicate the effect of temperature range during expansion, on which the theoretical cyclic efficiency is based; the figures would not agree exactly with those relating to cyclic efficiency because in this case the influence of the spent gases upon the explosion temperature and pressure is taken into consideration.

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Unreasonable Specifications

It is all right, of course, for the purchaser of machinery to make rigid specifications covering the performance and durability of that machinery. It by no means follows, however, that it is fair for the buyer to specify details of design which affect the performance and durability of the machine unless he is willing to shoulder the entire responsibility. If we expected to buy a gas engine, steam engine or any other power-plant equipment, we should be quite content to dictate the maximum continuous ability under stated conditions, the economy at stated loads, the limits of speed variation and the degree of builder's responsibility for breakages or failures within a reasonable period of time. We certainly should not expect or desire to dictate the method of regulation to be employed on a gas engine, for example, the material of which the cylinders should be made, or any other such vital features, and then expect any reputable builder to assume the responsibility for the results. And if we were building gas engines we should try to content ourselves with what orders we could get from people who are willing to accept satisfactory results without trying to dictate the methods of obtaining them.

Necessity for Good Work on Suction Piping

In a condensing system the large volume of cooling water used necessitates the use of large and, frequently, long suction pipes, which are almost always placed underground. Owing to the fact that flanged cast-iron pipe, or wrought-iron pipe with threaded or flanged ends, is in large sizes more expensive than cast-iron pipe with bell-and-spigot ends, and that the expense of laying is much less in the case of the bell-and-spigot pipe, this form is most frequently chosen.

To secure tight joints in this kind of pipe requires the conscientious exercise of rare skill. Lead joints, so-called, under pressure are easily inspected and leaks readily detected, but when under "suction" inspection is difficult and uncertain. Moisture to the slightest extent on the outside of a joint is evidence of leakage and may be attended to; but the leakage of air to the inside of the pipe is not so readily seen and may be quite large before it is suspected. When suspicion is confirmed it is still difficult, in some cases nearly impossible, to locate the leak. This is particularly the case when leaks are numerous and small. Where surface condensers are used, air-adulterated circulating water causes no serious trouble or impairment of condenser efficiency. It means only a slightly higher rate of speed for the circulating pump. But with the jet and barometric systems air leakage into the injection water means a reduction in vacuum that cannot be met by accelerated pump action or wider opening of the injection valve, for a vacuum can be vitiated by a surplus of water as well as by air.

All natural water carries in solution more or less air; an amount at times equal to five per cent. of its volume. This dissolved air is at once released under the influence of the vacuum in the condenser, and when to this is added the volume of free air which comes along with the cooling water where a leaky suction obtains, the difference between the vacuum due to the temperature and the actual vacuum is marked. It frequently happens that in a jet or a barometric condenser, where a vacuum of 26½ inches is expected, only 23 or 24 inches are realized, and as an increase of cooling water does not help matters, the condenser is charged with being inefficient or too small for the work; while, as a matter of fact, the real cause of failure is the excessive amount of air which leaks into the system through poorly made joints.

Where dry-vacuum pumps are installed with barometric condensers, a high vacuum is maintained by the extra work done by the air pump, and the real effect of the surplus air entering through the joints is felt only in the extra work put on the air pump, which falls short of its calculated efficiency.

Too much care cannot be exercised in the making of joints in the pipe supplying jet or barometric condensers with water, and no grade of skill in pipe laying, particularly in the making of the joints, whether screwed, flanged or bell-and-spigot, is too high to be employed.

Effect of Superheated Steam on Valves and Fittings

Steam-piping systems, which may be termed the arteries of the power plant, in the last twenty years have received practically as much attention as any part of the power-generating installation. The adoption of the standard thread and the manufacturers' standard for flanges, the almost universal acceptance of a fixed set of dimensions for fittings and valves for 100-pound pressures, and the use of standard pipe up to the 12-inch size, with bent pipe for flexibility, have made low-pressure piping an easy problem susceptible of a very satisfactory solution. With the "Van Stone," or rolled lap, and welded flanges, the 200-pound standard valves and fittings and the corrugated gaskets, both copper and steel, the high-pressure piping problem is practically solved.

Now a new Richmond has entered the field and with the increasing use of superheated steam the problem has had to be taken up anew, this time not with the idea of heavier, stronger and better work, but

with the necessity of finding a material better suited to the changed conditions of pressure and temperature.

The standard valve and fitting material, cast iron, has suffered in many cases a marked and continuous deterioration under the action of superheated steam. We have already illustrated this action in the columns of POWER and the reports of failures of valves and fittings are still coming in. Numerous explanations of this action have been offered, but are not satisfying.

To obviate this trouble manufacturers are offering valves and fittings of various qualities of cast steel which, up to the present writing, have presented no serious failures. These steel fittings have been in service approximately three years, and while it cannot be maintained that the problem is solved, at least a very satisfactory result has been obtained. At the outset the cost of this material was very high, but the increasing demand has led more manufacturers to embark in the steel-casting business and it will be only a short time before steel valves and fittings may be obtained at reasonable advance above the price of the cheaper material.

It must be added, however, that a number of manufacturers are endeavoring to discover the cause of the deterioration of cast iron by superheated steam, so far without success.

Through Bracing

A large class of engineers, who have made a study of steam-boiler construction, and particularly those who have been brought up under marine-boiler influence, are predisposed to advocate the through form of bracing wherever this type can be put in. It appears that the chief advantage of this form lies in the fact that the strain produced by the pressure on the supported surface causes a direct tensile stress in the brace, while in the crowfoot form the angularity of the brace detracts from its effective holding power. It must be admitted that when considered as an abstract mechanical problem the above statement is correct, but it is doubtful if this is true under many conditions met in boiler practice. That this supposed increased value has considerable weight is evidenced in the new Massachusetts rules which allow twelve and five-tenths per cent. stress on the through form of brace above that allowed on the crowfoot form, when both are of weldless-steel construction and over one and one-quarter inches in diameter, this increased allowance being reduced to six and six-tenths per cent. when the braces are one and one-quarter inches in diameter or less.

Notwithstanding the established prestige of the through form of bracing, it would appear that there are often reasons why the solid crowfoot form could be substituted for it to advantage. First, in the matter of effectiveness, through braces are often subjected to strains far in excess of those due to direct pressure loads. This is particularly true where braces are used in the steam space and where they are very long and of small diameter. In such cases the braces are often subject to serious vibration, due to synchronism between the period of the brace and that of the varying pressure on the boiler heads and to the impingement of water thrown up by the liberation of steam. That the stresses caused by this vibration are severe is indicated by the fact that they are often found to be stretched after considerable use and sometimes broken near the point of connection to the heads.

When through braces are pinned to one head it is often found that the connections have been strained to such an extent that the brace is too loose to be effective. It is not practicable to space through braces closely enough together properly to distribute the load, and it is therefore necessary to stiffen the heads with angles, or channels, which add to the difficulty of making a tight connection at the brace ends. Through bracing interferes with the proper cleaning of the interior surfaces, which in most cases is a serious defect.

On account of the inadvisability of riveting the blade of a crowfoot brace to the interior of the shell immediately above the fire, in return-tubular boilers the through brace below the tubes is practically indispensable. It appears that if the assumed superior strength of the through brace is not a reality, and other considerations render the crowfoot form more advisable, it should not be discriminated against.

Clean Feed Water

Of all requirements for efficient operation in the boiler room, clean water is by no means the least. Much attention is given in the modern plant to the selection of coal adapted to the particular design of grate in use and to the specific conditions of draft existing. The coal question is, of course, important and is worthy of all the consideration it receives; still, there are other factors equally important and demanding the same careful attention to detail. One of these factors is the removal of sand, leaves and other débris from the suction water of a plant. The importance of such a step is generally recognized, but is not always given careful attention. Inoperative valves, deterioration in packing and bushings, worn cylinders and boilers overloaded with sludge tell the tale, and bring home to the engineer the results of such neglect in a way not to be forgotten.

Oftentimes but little pretension is made of removing suspended matter from river or pond water, when either is to be used in the condenser, and even when used for boiler feed nothing is done in the way of purification until the water reaches the boiler room. It is always a good plan to strain the water at the suction inlet and, when the size of the plant will warrant the expenditure, a filter bed of sand and gravel is preferable. Screens are second choice but, if properly installed, should prove more or less effective. They should be counterbalanced and arranged so that they may be easily raised for cleaning. In raising a screen for this purpose a certain amount of debris will drop off and pass on to the next screen, so that it is better to have at least three screens in series, or even four would not be extravagant, but would allow the operator the privilege of cleaning or repairing a screen at his leisure.

Ordinarily screens are much too small for the service demanded of them. It does not take long to choke up the mesh and almost entirely shut off the supply of water. The finer the screen the sooner will this condition be reached, therefore the more need for a screen of large area. In a certain plant a screen of 1-inch mesh and ¼-inch wire was used, and with a ratio of suction area to screen area of 1 to 13, or 1 to 7, when compared to the openings in the screen, fairly satisfactory results were obtained. Better results would have been secured with a larger screen, and at that the ratios given are considerably larger than found in common practice. After passing through the screens the water should flow to a well or basin of sufficient area to allow the small particles of dirt to settle, and in addition a screen of fine mesh over each suction pipe is advisable.

On first sight such precaution in protecting the suction inlet might appear unnecessary, but it is perfectly apparent that whatever purification is effected externally will not be necessary within the plant. Smaller expenditures for purifying apparatus in the boiler room, deterioration at a less rapid rate and the saving of considerable trouble and annoyance in the operation of the plant will result.

The management of a power station recently experienced considerable trouble from the breaking of boiler-tube cap bolts on the water-tube boilers. The bolts looked all right, but every time a boiler was cooled down and brought up to steam again a number of the bolts would break off short. The matter became so serious that several bolts were sent to Arthur D. Little, of Boston, an expert chemist, for analysis. He discovered that the bolts were made of overheated steel instead of the best quality of wrought iron, for which the company had paid and supposed it was obtaining.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The Lazier Vertical Gas Engine

The accompanying engravings illustrate the latest type of vertical gas engine built by the Lazier Gas Engine Company, of Buffalo, N. Y. The engine works on the four-stroke cycle and is of the single-acting two-cylinder type, as indicated in Fig. 1, which shows an engine built for belt driving. Both of the valves work in cages set into the cylinder head, as indicated in Fig. 2, which is a vertical section of one side of the engine with the valve-actuating mechanism omitted. The valves are operated by short rocker arms and the usual cam shaft; but the latter is located along the tops of the cylinders instead of lower down on the frame, which is the more common custom. This arrangement, which is illustrated on a larger scale in Fig. 3, eliminates long push rods with the attendant disadvantages of that construction. The cam shaft is driven through spiral gears by the vertical governor shaft, the location of which is shown in Fig. 1. From the ends of the cam shaft the igniters are actuated by means of eccentrics and short push rods.

The cam shaft carries in addition to the regular operating cams a set of compression-relief cams which, when shifted into the position for starting the engine, hold the exhaust valves open during a part of the suction stroke and thereby reduce the compression; after the engine has "picked up," the compression-relief cams are thrown out of action and the engine operates with normal compression. The handle for shifting the relief cams into and out of action is shown in Fig. 3 near the left-hand end of the trough in which the cam shaft is located.

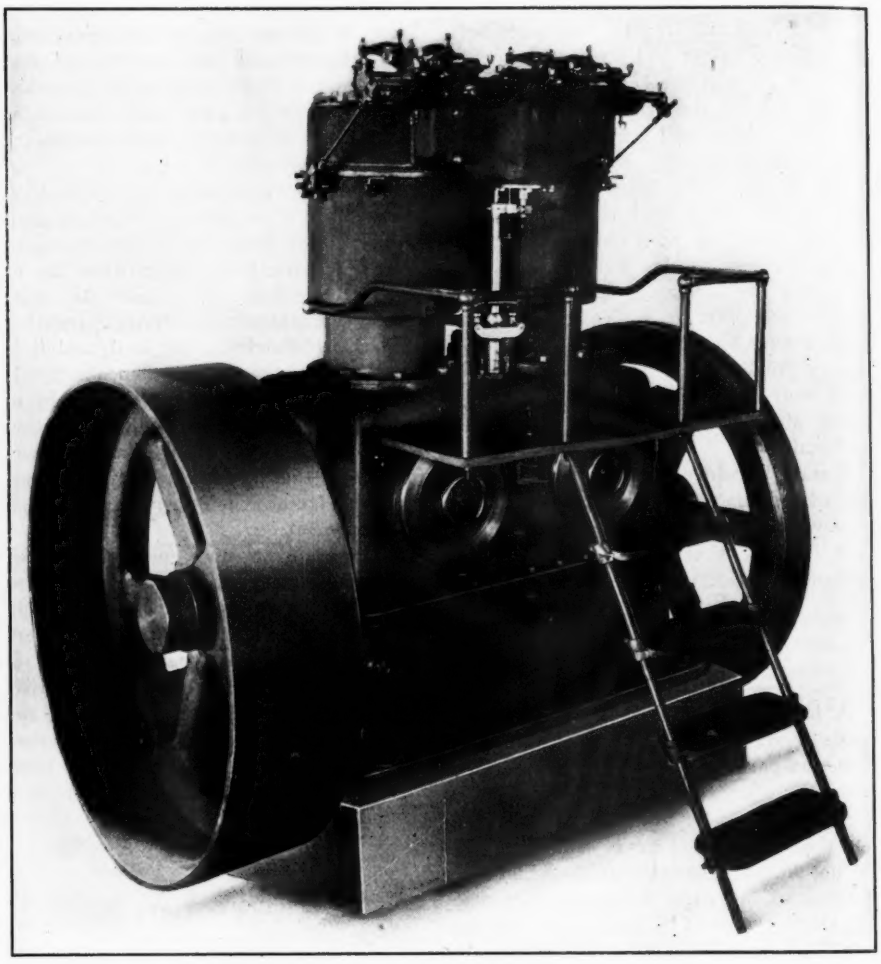


FIG. 1. LAZIER GAS ENGINE

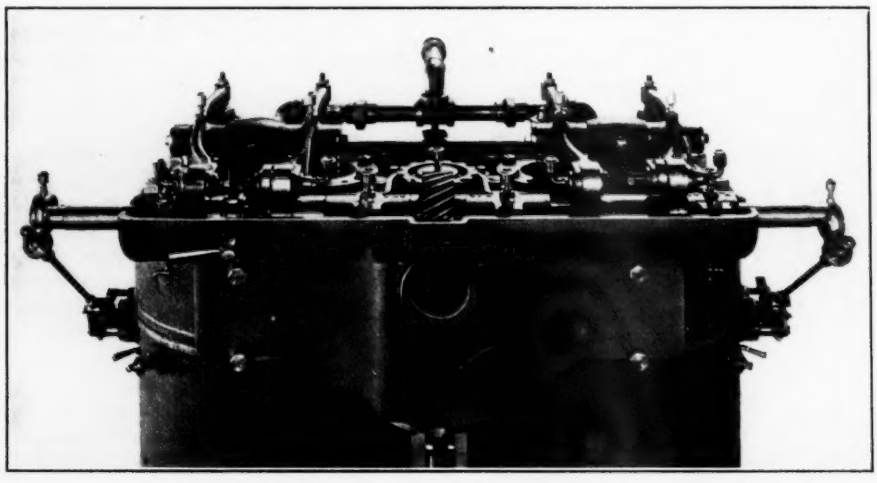


FIG. 3. LAZIER CAM SHAFT AND VALVE GEAR

The igniters are of the make-and-break variety; the construction of the operating mechanism is shown by Fig. 4. The tripping finger or trigger is pivoted near the end of the rocker arm and its upper end is provided with a 45-degree extension which engages with a tripping roller immediately above it and is thereby pressed over to the right until the lifting block is carried beyond the end of the actuating lever; then the spring snaps the lever and the movable electrode back to the idle position, separating the electrodes and making the spark between their contact points. The short finger with a right-angle lug at its end and located

immediately below the actuating lever is mounted on the stem of the movable electrode; this finger and the actuating lever are acted on by a single spring which tends to draw their ends together. When the lever is lifted by the trigger, the spring forces the electrode finger up with it until the movable electrode comes in contact with the stationary one and its motion is stopped; when the lifting block is pulled out from under the actuating lever by the tripping roller, the spring snaps the actuating lever downward against the electrode finger, giving a quick-break effect at the electrode contacts.

through the ports into the intake manifold, being agitated by passage through the narrow openings and the mixture thereby improved. The circular grid valve is connected rigidly to the linkage controlled by the governor, and the stem of the disk valve is adjustable up and down in the hub or sleeve of the grid valve. By this means the relative positions of the two valves, and thereby the proportion of gas to air in the mixture, is variable to suit the fuel being used.

The use of the disk valve further provides automatic means for varying the quality of the mixture as the load varies.

them. It may be pointed out, however, that the cranks, which are located in the same plane, are counterbalanced by weights attached to the backs of the cheeks, thus eliminating the tendency to lateral oscillation which exists when counterbalancing weights are used in the flywheel. The vertical countershaft on which the governor is mounted is driven through spiral gears, as shown in Fig. 2. Lubrication of the internal parts is effected by the splash method. The rocker arms are lubricated by small grease cups and the cam shaft revolves in an oil trough, which lubricates the cams and gears, but the shaft bear-

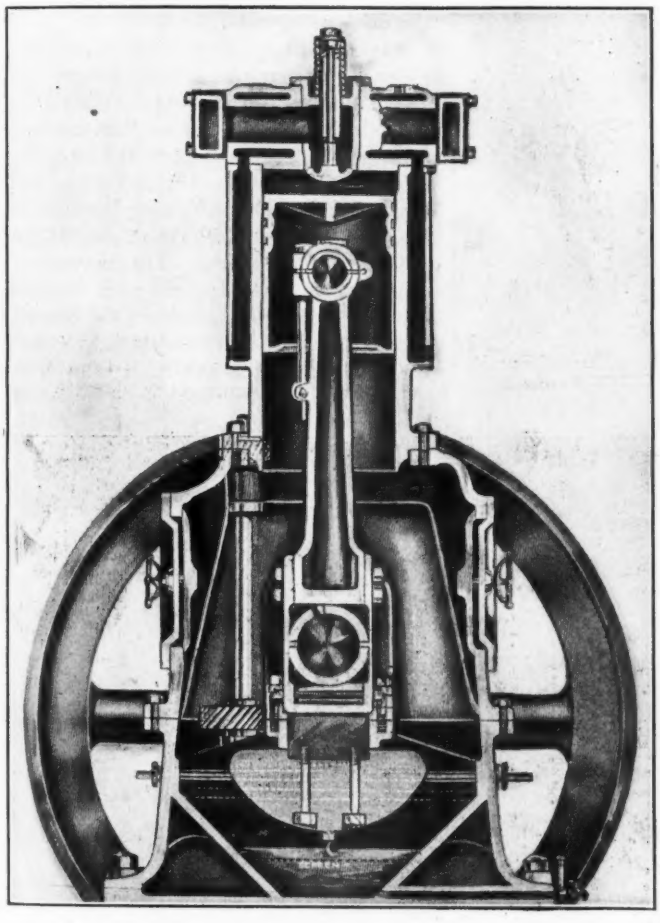


FIG. 2. SECTIONAL ELEVATION OF ONE CYLINDER AND CORRESPONDING PARTS

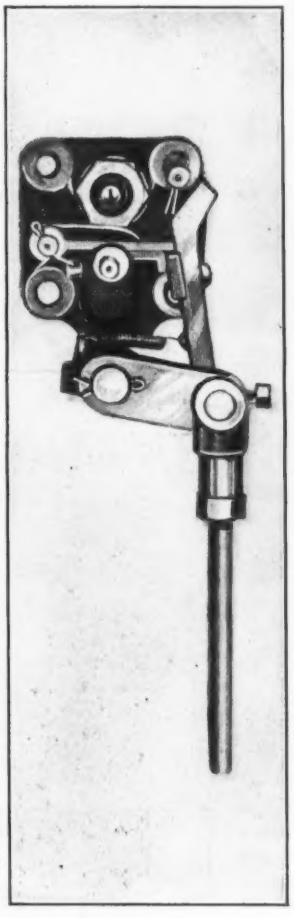


FIG. 4. LAZIER IGNITER

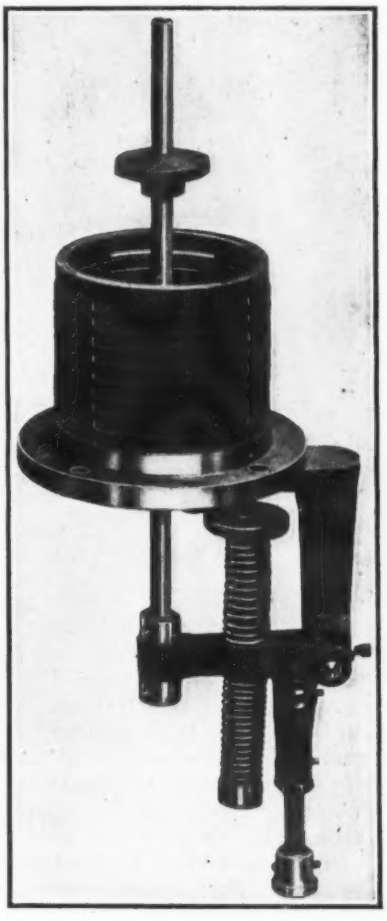


FIG. 5. LAZIER MIXING AND SPEED-REGULATING VALVE

The speed is regulated by means of a combination throttling and mixing valve controlled by the governor; this is shown in Fig. 5. The circular cage with ports through its wall is stationary and located in a chamber opening into the intake manifold. The air enters this cage freely at the top and gas enters it through a port controlled by the disk valve shown midway of the upper valve stem. Mounted on a sleeve on the valve stem is a circular grid valve inside the cage, and its position is varied vertically by the governor to cover more or less of the port openings in the wall of the cage. The air and gas are mixed inside the valve and pass

With full load the ports in the wall of the mixing-valve cage will be wide open and the gas port will be opened by the maximum amount proper for the fuel being used. When the load decreases, the ports in the mixing-valve cage are partially closed by the governor and the disk valve also partially closes the gas port, thereby impoverishing the mixture slightly and keeping the compression higher than it would be if regulation were effected solely by throttling the mixture.

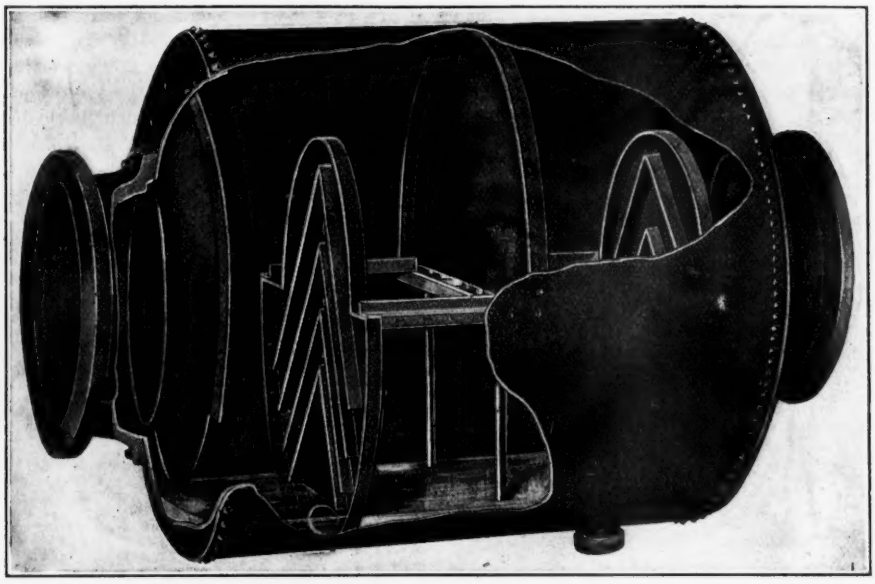
Fig. 2 shows the mechanical construction of the cylinders, pistons, connecting rods and crank case so clearly as to render unnecessary a detailed description of

ings are provided with individual cups, as shown in Fig. 3. The crank shaft is a one-piece forging of open-hearth steel, with pins somewhat larger in diameter than the main journals. The crank case is split horizontally in line with the center of the crank shaft, to facilitate the removal of the latter if it should ever become necessary. The flywheel is of the split-hub type, but not divided at the rim.

These engines are built in sizes ranging from 60 to 150 horsepower using natural gas, and from 45 to 115 horsepower using producer gas. The piston speeds range from 550 feet per minute in smaller sizes to 625 feet per minute in larger sizes.

Hoppes Horizontal Oil Eliminator

The Hoppes eliminator is especially designed for use in exhaust pipes of large size, for either vacuum or high-pressure service. The shell of the machine is made of flange steel, the heads and interior construction being of the same material, but the flanges for the pipe connections are of cast iron. The exhaust enters at the left-hand side and passes out at the right. As the oil and water for the most part follow the surface of the pipe, the inlet nozzle is made taper, and an intercepting plate, as shown in the illustration, is used to deflect the entrainment from a straight course into the eliminator, and direct it to the bottom of the shell.



HOPPES HORIZONTAL OIL ELIMINATOR

After the steam enters the shell, it strikes a baffle plate, the face of which is provided with a number of angle-iron strips which catch and hold the oil or water and carry it to the bottom of the shell. The exhaust steam, after passing over this baffle plate, is turned downward by another plate across the upper half of the shell, this plate being provided with an intercepting trough at its lower edge, which is kept partly filled with water, the excess water and oil being carried to the bottom by the drain pipes shown.

After passing the second baffle plate, the steam is prevented from flowing directly out of the outlet by another plate similar to the first one, and the oil and water are prevented from following the surface and escaping through the outlet by a short inwardly projecting nozzle. A small amount of water is always held in the bottom of the shell, as it has been found that this aids in catching and retaining the oil. The intercepting troughs partly filled with water stop the oil from creeping by.

This eliminator is manufactured by the Hoppes Manufacturing Company, Springfield, O.

Westinghouse Special Circuit Breaker

The accompanying engraving illustrates a special application of the standard Type CC circuit-breaker of the Westinghouse Electric and Manufacturing Company. This arrangement was devised in order to meet the requirement for a double-pole circuit-breaker which could be opened either by hand or by a magnet controlled from a distance, and which would also open automatically in the event of an increase in current beyond the maximum allowed in the circuit; the construction had to be also such that when the circuit-breaker was opened from a distance, it could be held open from that point regardless of efforts to close it by means of the resetting handle. The circuit-breaker was to protect a large motor, and the remote-control switch to open it and hold it open was located at the machine driven by the motor, under the control of the machine operator.

The circuit-breaker consists of two single-pole mechanisms, each having an automatic overload tripping coil, a handle located between the two mechanisms and arranged to close and open the two circuit-breakers, and a solenoid (shown beneath the handle) for opening the circuit-breakers in response to the closing of the switch at the machine. The mechanism in the middle is exactly the same as each of the tripping mechanisms of the circuit-breakers, and when it is tripped, by either the solenoid or the handle, it trips both of the circuit mechanisms; similarly, when

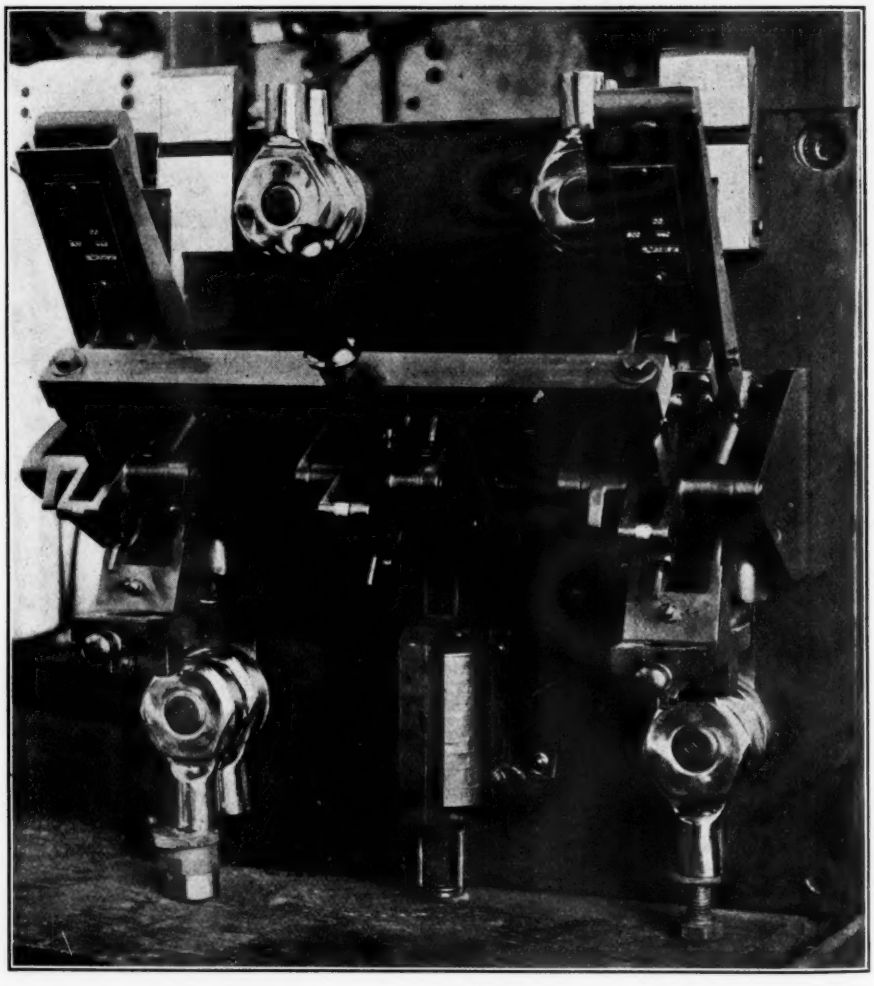


FIG. I. SPECIAL APPLICATION OF THE WESTINGHOUSE TYPE CC CIRCUIT-BREAKER

either of the two circuit-breaker coils trips its own mechanism, that trips the other circuit latch and the middle latch. When the mechanisms are tripped by the

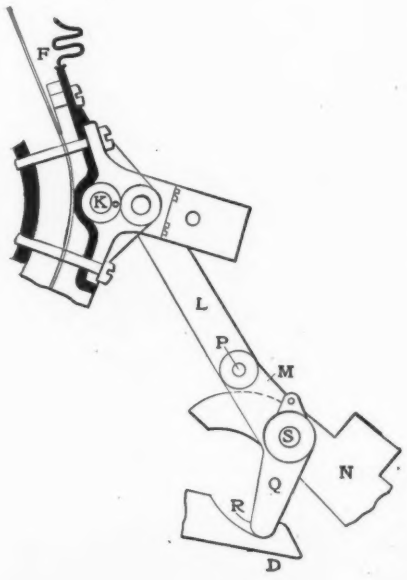


FIG. 2

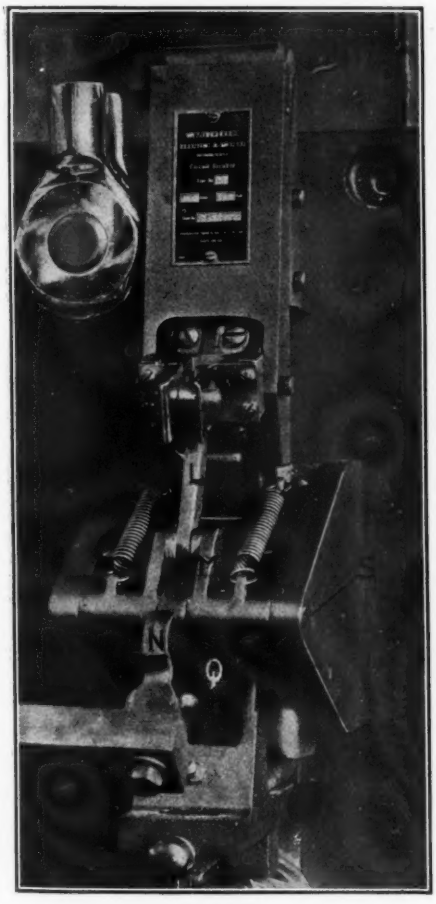


FIG. 3.

remote-control solenoid, the handle is caught by a latch which holds it in the open position as long as the solenoid remains excited. When the remote-control switch is open, the latch releases the handle, which may then be operated in the usual way.

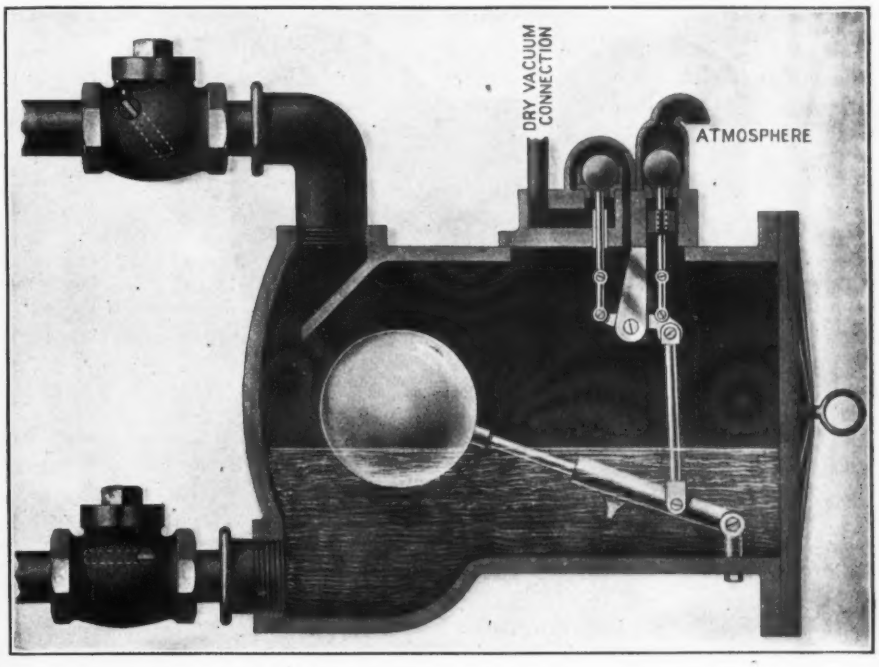
The arrangement of one of the circuit-breaker mechanisms is shown by Figs. 2 and 3. The lever N is one of the three which are bolted to the handle bar. It is mounted freely on the spindle S, on which the twin bell-crank $M\,Q$ is also swiveled. The end M of the crank is attached by a pin P to the end of the link L which opens and closes the contacts. The end Q of the bell-crank carries a roller R which engages with a latch or dog D, the end of which is drawn upward by a spring and may be thrown downward by the trip (not shown). Figs. 2 and 3 show the mechanism in its closed position. If the overload coil, through its trip, throws the dog D down, releasing the bell-crank arm Q, a pair of heavy springs (see Fig. 3) pulls the arm M inward and opens the contacts. When the arm M moves inward it carries with it the curved end of the lever N, and that end of the corresponding lever of the other mechanism strikes the dog D of that mechanism and throws the contacts open. Raising the handle as shown in Fig. 1 moves both of the levers N and trips both dogs D simultaneously; the solenoid, when energized, raises the handle, with exactly the same result, of course.

When the circuit-breakers are open, the curved end of the lever N on each one is down (the handle being up). When the handle is thrown down, the curved end presses the fulcrum P of each breaker outward, pushing up each link L and closing the contacts.

The Strong Vacuum Trap

The Strong vacuum trap consists of a large circular body, 18 inches outside diameter and about 32 inches long, with an inlet and outlet of any size desired from 3½ inches down. A ball float operates a lever which, in turn, operates two ground, brass balls, one controlling the atmospheric pressure and the other controlling the vacuum pressure.

The valve seats are screwed into the valve chamber and are made of Government bronze. The valves are readily accessible as shown by the accompanying sectional illustration of the trap. It is not likely that dirt will get between the ball and the ball seat, as they are several inches above the water line and almost the length of the trap away from the inlet.



THE STRONG VACUUM TRAP

The illustration shows the trap discharging. The ball controlling the atmospheric inlet is shown to be off its seat. Atmospheric pressure is, therefore, established in the trap, and the water in the trap will flow out by gravity through the swing check valve.

The valve rod operating the vacuum ball is shown to be in contact with the ball. The atmospheric condition in the trap is transmitted through the valve port into the cap covering the vacuum ball. The vacuum ball is, therefore, held on its seat by a pressure equal to the difference in pressure between the atmosphere and whatever vacuum is being carried, multiplied by the area of the ball seat; this pressure with a 26-inch vacuum is 20 pounds.

As the water flows out of the trap, the tendency of the ball float is to drop with the water line. It cannot do so, however, because the vacuum rod is in contact with the vacuum ball and cannot lift it, as it is held on its seat by the pressure mentioned. The water continues to flow out of the trap, dropping away from the ball float until the weight of the ball float and its leverage are sufficient to lift the vacuum ball. When this occurs the ball float drops to the new water line. The vacuum ball is lifted off its seat about ½ inch and the rod operating the atmospheric ball drops the same distance, permitting the atmospheric ball to seat.

The trap is thus closed to the atmosphere and open to the vacuum through the dry-vacuum pipe. In three or four seconds the same vacuum will be established in the trap as is maintained in the vacuum system being drained. Water will then drop by gravity from the system into the trap.

The ball float will rise with the water line until the vacuum ball is about ⅛ of an inch off its seat, and the rod operating the atmospheric ball comes in contact with that ball. The same conditions now exist with the atmospheric ball as existed with the vacuum ball. The atmosphere on one side of the ball and the vacuum on the under side present a total pressure of 20 pounds holding this ball on the seat.

The ball float cannot lift the atmospheric valve under these conditions. The vacuum valve thus remains open and the water continues to flow into the trap, flooding the ball float, which cannot rise with the rising water line. When the ball float is flooded to such extent that its increased buoyancy and its leverage are greater than the pressure holding the ball valve on the seat, it will then raise the ball. The atmospheric ball is thus raised about ½ inch from its seat and permits the vacuum ball to drop to its seat.

The instant the ball is lifted from its seat the pressure of 20 pounds disappears, as the ball is then in equilibrium, the only pressure left being the weight of the ball, about ¾ of a pound. A variation of 6 inches in the water line is thus obtained, giving a capacity of 8 gallons per discharge. Three discharges per minute are possible, giving a capacity of 24 gallons per minute. This trap is manufactured by the Strong, Carlisle & Hammond Company, 336 to 344 Frankfort avenue, S. W., Cleveland, Ohio.

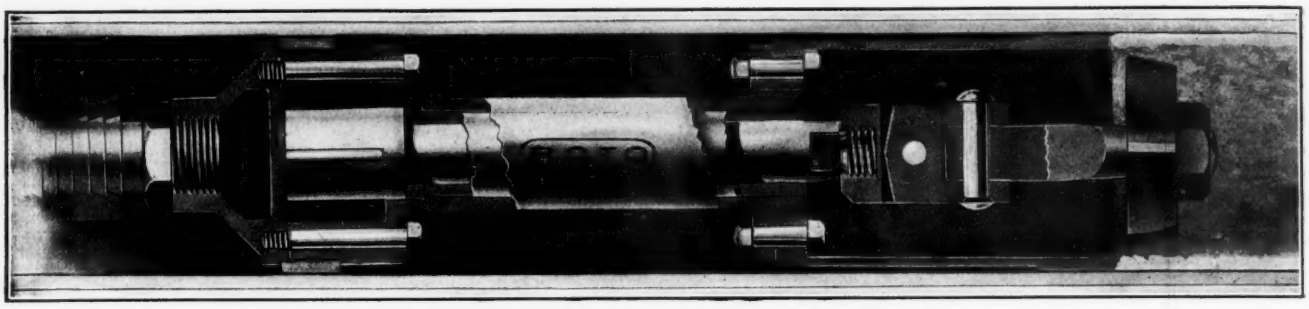


FIG. 1. SHOWING GENERAL CONSTRUCTION OF "ROTO" TUBE CLEANER

"Roto" Tube Cleaner

Following is a description of a new air- or steam-driven tube cleaner, the general construction of which is shown in Fig. 1, in position in a straight 4-inch water tube containing a heavy deposit of hard scale. The power is developed in a 2-inch cylinder 1½ inches long, containing a slotted piston and a single sliding blade. The cylinder bore is formed in the shape of a heart, the edges of the sliding blade exactly fitting it in every position during the revolution of the eccentric piston.

The piston shoulder is floated on a thin film of filtered oil, saturated with air or steam. Oil put in at the ball valve soaks into lampwicking in the oil receiver, and a very small jet of compressed air or steam admitted on top of the lampwick passes through it and conducts the oil under the piston shoulder, which it lifts a very little against the thrust of the air pressure and the weight of the tools and escapes in a thin film, thus forming practically a frictionless thrust bearing or step.

The single blade balances itself and admits of large eccentricity and piston displacement, being designed to allow the motor to run perfectly cool at very high speed. The motor is self-starting in all positions and has no spring or air pressure to force the blade against the cylinder walls.

This cleaner uses a hardened-steel sizing shield, carried by the motor and extending to a point close behind the cleaning tool which is thereby held in position to strike and remove the scale, and automatically to move on through the tube. With the sizing shield close behind the tool there is little likelihood that the operator will leave the cleaner in one position long enough possibly to damage the tube. It is not necessary to reduce its external diameter to pass through some one bad tube in the boiler, and so sacrifice thoroughness in cleaning the other tubes, as extra sizing shields are supplied, and these are quickly exchanged to fit the tubes being cleaned.

Where scale is very heavy, it may be first roughed out with a small sizing shield following a suitable tool, then with a larger shield. The tubes may be finished and polished by the same cleaner equipped with a larger shield and a finishing or polishing head suitable to the purpose. In short, the new cleaner with assorted shields is equivalent to several cleaners of different sizes. The cleaning should be

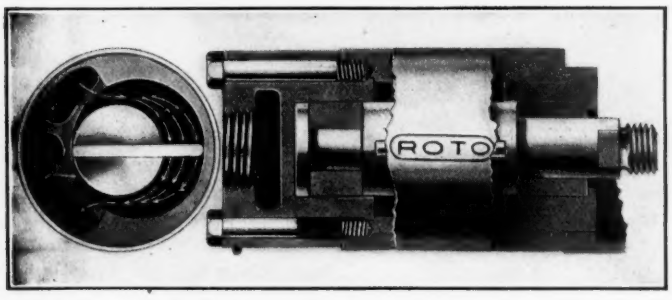


FIG. 2. DOUBLE-BEARING CLEANER

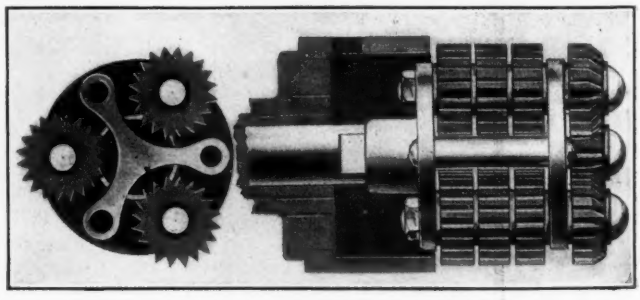


FIG. 3. MULTIPLE-EFFECT POLISHING HEAD

done with the largest shield that will pass through the tubes when cleaned, so as to remove all the scale without cutting, grinding or bruising the already cleaned tube surfaces.

The cutters are formed of tempered high-speed tool steel. Where very heavy scale is encountered, a sharp pointed drill nut is substituted for the hexagon nut shown in Fig. 1. Several types of head, suitable for all purposes and including drill heads, cone-cutter heads and arm heads, are furnished.

Fig. 2 shows a view of a double-bearing cleaner made in small size for locomotive tubes, etc., the cross-sectional view showing the general construction of the air-driven motor. Fig. 3 shows two views of the "Roto" multiple-effect polishing head.

This apparatus is manufactured by the Roto Company, 62 Market street, Hartford, Conn.

The "Erieco" Engine Valve

The valve herewith described is especially adapted to single-cylinder high-speed engines of the automatic cutoff type, and has been used for the past three years in the "Erieco" engine, built by the Erie Manufacturing and Supply Company, Erie, Penn.

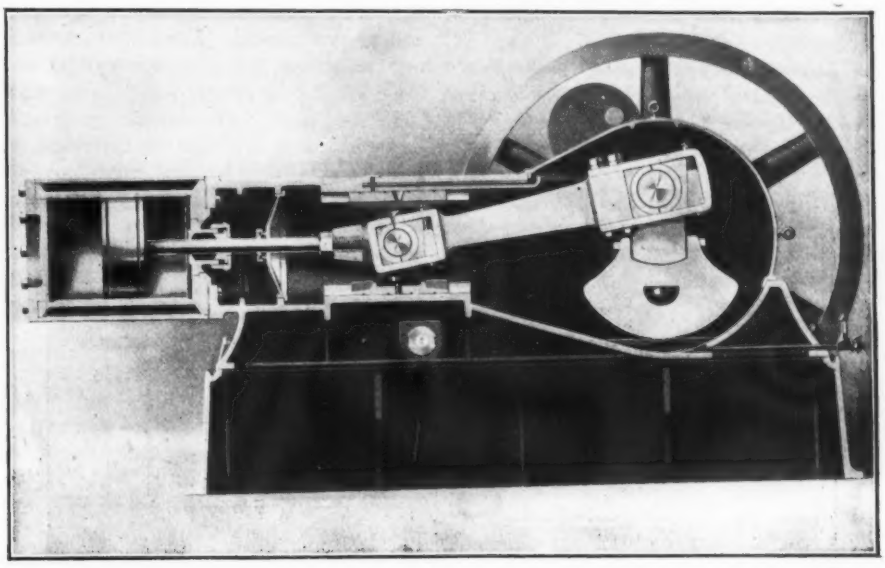


FIG. 1. SECTIONAL VIEW OF "ERIECO" ENGINE

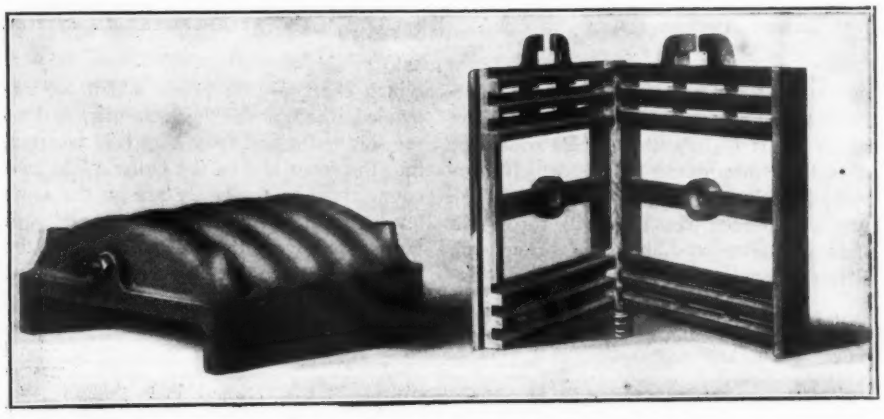


FIG. 2. PRESSURE PLATE AND HALVES OF VALVE

It is a balanced valve of the flat slide type, riding in a pressure plate. It is claimed that it takes up its own wear, and remains steam-tight at all ranges of steam pressure. It is made in two pieces, having interlocking projections its entire width. The interlocking projections, having surfaces in opposite directions, are said to be held in steam-tight contact, owing to the difference in the exposed areas of the end of each half of the valve. By referring to Figs. 2 and 3 it will be seen that there are three projections at each end of both parts of the valve, forming five sides. Three of the sides at each end are surfaced to a steam-tight contact; to accomplish this the other two surfaces must spread.

As the valve wears it is held in contact with the pressure plate and seat, owing to the steam being admitted between the two halves of the valve. Steam is admitted between the halves of the valve through its ports, the location of which is such that the proper pressure is said to be maintained at all positions of the valve. The same principle of different areas is applied to the top and bottom of this valve.

It is claimed that the valve is kept steam-tight by the pressure under which it is operating, whether boiler pressure, compression, decreasing pressure due to expansion, atmospheric, or back pressure, and that this valve does away with the expense of frequent scraping by the engineer, to keep it tight, and the trouble of shutdowns occasioned by this work. This valve is sent out with "Erieco" engines.

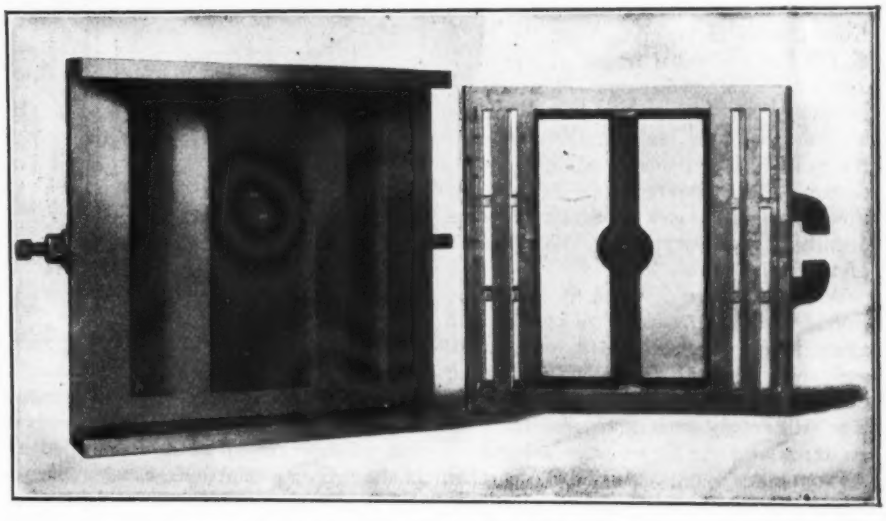


FIG. 3. PRESSURE PLATE AND VALVE

The Orvis Furnace

In the accompanying illustrations is shown the Orvis furnace, which was designed by Orland D. Orvis, of the Orvis Economy Furnace Company, 21 Park row, New York City. The furnace consists of two principal features, an arrangement of air piping and one steam jet to produce an induced draft, and an independent arrange-

ment of piping to circulate the water in the boiler. The latter arrangement is said to stop the formation of scale, and after the system has been installed for a short time cause the old scale to drop off. The illustrations show the furnace adapted to an ordinary tubular boiler.

Differing from usual practice, the blowing device has been placed near the bridgewall instead of at the front of the furnace, or underneath the grate, and the air blast in passing through the contracted space or throat between the top of the bridgewall and the shell, induces a draft and brings the mixture of air and steam in contact with all the gases from the fire. The draft arrangement consists of the pipes *A* and *B*, the former being an air pipe as far down as the elbow, and the latter a small steam pipe, ending in a small jet introduced at the elbow of the air pipe. A small jet of steam issuing from the steam pipe causes a vacuum in the larger pipe, and in drawing the air from the boiler room through the hood *C*, fills the horizontal length of pipe with a mixture of air and steam. This mixture escapes with considerable velocity through a number of blasts in thin sheets toward the rear of the boiler, and in passing through the contracted area indicated in the drawing, increases the draft and consequently the evaporation and horsepower of the boiler.

With the device designed by Mr. Orvis embodying the vacuum principle the amount of steam required is very small, and some idea of the quantity will be obtained when it is stated that a 1-inch pipe will supply sufficient steam to operate thirty-two 100-horsepower boilers.

From a test recently made by Albert A. Cary, at a prominent plant in Newark, N. J., equipped with the Orvis system, it was reported that the blower could increase the steaming capacity of the boiler about 25 per cent., so that a considerable gain would be effected in the horsepower develped and the amount of steam produced per hour, which in a plant with a number of boilers would mean that the capacity could be increased sufficiently to avoid the installation of a new boiler.

Another claim for the device is that it will prevent smoke. From the construction shown in the illustration, it is apparent that the gases formed from combustion must pass rapidly in a thin sheet under the straight arch or baffle wall over a bed of incandescent fuel, which consumes the larger part of the smoke. The gases must then pass upwardly through a narrow passage and above the bridgewall, where they come in contact with a mixture of superheated steam and heated air in the proper proportions, causing the remaining particles of carbon to ignite and burn and in this way prevent any smoke from reaching the stack. The device then has apparently four advantages: To increase the draft, evaporate more water, remove scale and consume the smoke. It should, therefore, be of use in an overloaded boiler room, or where enough draft is not available.

The other feature of special prominence was the circulating tubes shown at *D* in the illustrations. Water is taken from the rear of the boiler, as shown, and caused to flow across the furnace in 4-inch charcoal-iron tubes, which are expanded into suitable headers bricked into the side walls, and from here it is returned into the front end of the boiler. The two connections to the boiler are on the same level, are below the water line and still far enough from the bottom to avoid the sludge and whatever impurities may have settled to this location. To produce the circulation, the tubes across the furnace are tilted slightly, so that the heated water will have a tendency to flow in one direction, and that toward the front of the boiler. By this means a rapid circulation is set up in the boiler and scale formation is prevented.

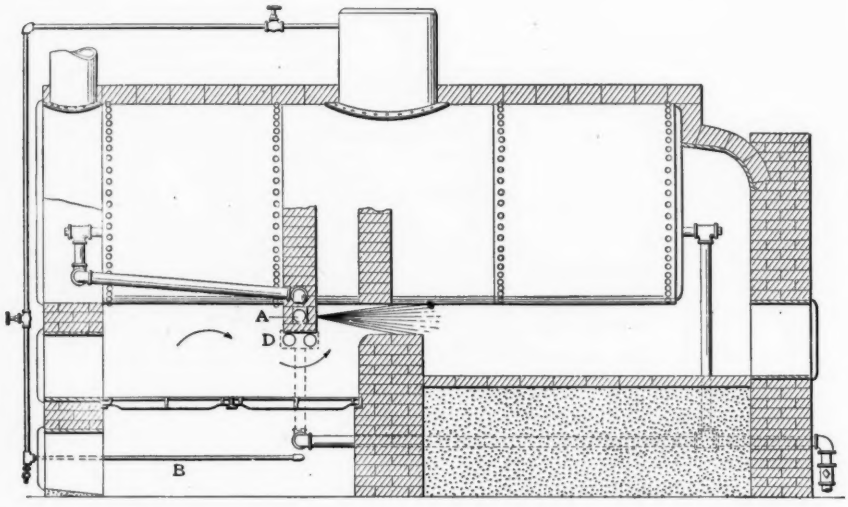


FIG. 1. ORVIS FURNACE ADAPTED TO RETURN-TUBULAR BOILER

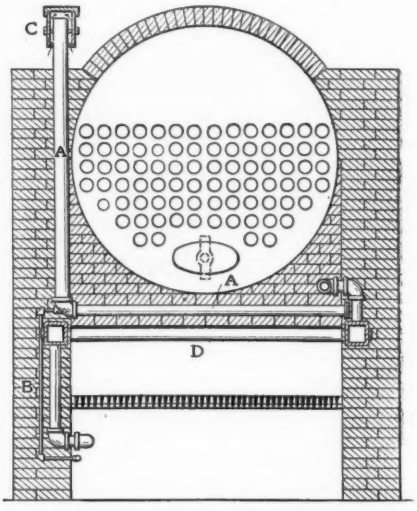


FIG. 2. PIPING ARRANGEMENT IN SETTING

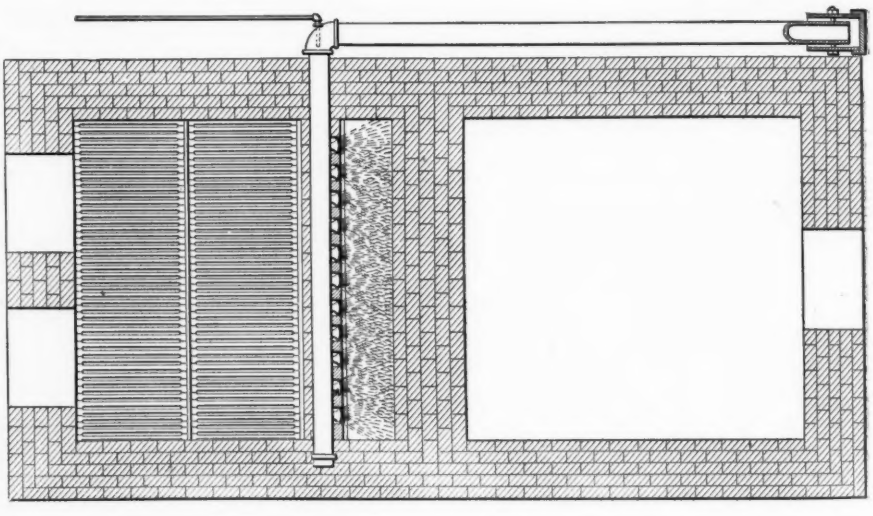


FIG. 3. SECTIONAL PLAN OF BOILER SETTING

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

What Is Meant by Centennial Rating

Will you please explain what is meant by a boiler horsepower centennial rating?

C. D.

The centennial rule, so called, declared a boiler horsepower to be the evaporation of 30 pounds of water at 100 degrees temperature into steam at 70 pounds pressure in one hour. It is a measure of the rate of work and is equivalent to the evaporation of 34½ pounds of water from a temperature of 212 degrees into steam at atmospheric pressure.

Comparative Heating Value of Wood

What is the heating value of wood as compared with good soft coal?

D. B.

Two and one-quarter pounds of dry wood contains about the same number of heat units as a pound of average bituminous coal. It is necessary that the wood be thoroughly dry. It seems to make little difference what kind of wood is used, as, pound for pound, poplar is as good as hickory or oak. Some experiments have shown the heat value of perfectly dry wood to be 0.4 that of carbon.

Concrete for Engine Foundation

I wish to build an engine foundation of concrete. What proportions of cement, sand and broken stone shall I use?

C. D. M.

One part, by measure, of good hydraulic cement to three parts of coarse, sharp sand and six parts of clean, broken stone that will pass through a screen of 1½-inch mesh. Spread a batch of stone about 6 inches thick on a floor of plank and wet thoroughly. Mix a stiff mortar with the sand and cement and spread it evenly over the stone. Then, with shovels, turn until thoroughly mixed, wheel or carry it to the form and tamp, particularly around the outside next to the form, to prevent the formation of holes. If it is necessary to let the work stand unfinished over night, the top should be left as rough as possible and well wet before putting on fresh material.

Vacuum in Condensers

In my plant I have a jet condenser which until recently would show only 24 inches vacuum. Another engine was bought with a surface condenser, and the suction pipe which supplied the jet condenser was extended to furnish water for the other. When both condensers are running I get 27 inches vacuum in the jet condenser, but when it is running alone I get only 24 inches. Can you explain this?

F. C. A.

The suction pipe leading to the condensers leaks. When the jet condenser is running alone all the air which is drawn in through the leaks goes to the condensing chamber and expanding there reduces the vacuum. When the surface condenser is running the air is carried past the outlet to the first condenser which gets "solid" water, and a vacuum, due to the temperature of the condenser, is obtained. In order to get good results with a jet condenser it is necessary that the suction pipe be absolutely air-tight. Any air entering the condenser with the injection water produces the same results that come from air leaking through stuffing boxes or exhaust-pipe joints. It expands in the condenser and reduces the vacuum.

Flywheel Energy

Is the energy stored in a flywheel during one portion of the revolution given back again without any loss during the rest of the revolution, assuming constant speed and eliminating friction?

G. F. D.

The energy given to the flywheel in the earlier portion of the stroke is delivered to the shaft during the later portion of the stroke when the mean pressure is lower, and this without any other loss than that of friction. You cannot assume the constant speed because the ability of the flywheel to receive and to give back energy lies in an allowable speed variation. The wheel is speeded up under the high initial pressure and slows down as it gives up the energy thus required later in the stroke. The energy necessary to get up a given velocity is

$$E = \frac{W V^2}{64.32},$$

from which it is easy to figure the amount of energy which a flywheel of a given weight with a given variation in velocity will distribute.

Cause of Pound in Ammonia Compressor

What causes an ammonia compressor to pound when it is started up after having been shut down for a few days?

E. W.

We are inclined to think that a pound in the compressor cylinder occurring under such conditions would be due to entrained liquid returning to the compressor with the return gas. If the piston rods are found to get very cold, the discharge pipe being unusually cool, and the stuffing box shows a tendency to leak, this is undoubtedly the correct explanation. This liquid may either leak by the expansion valves into the cooler while the machine is shut down, or it may have been pocketed somewhere while the machine was in operation, in which latter case the low temperature of the insulation or possibly ice surrounding the part of the piping forming the pocket might have allowed it to collect faster than it could evaporate.

When the machine is shut down a portion of this residual ammonia will evaporate and increase the pressure on the remainder sufficiently to prevent its evaporation even at a higher temperature of the surrounding insulation, or after the ice has melted off, as the case may be. When the machine is again put in operation and the back pressure is quickly reduced, the comparatively high temperature liquid will begin to boil rapidly, and, as in the case of a boiler that is being "crowded," a certain amount of liquid is bound to pass off with the vapor. If parts of the piping can be found that frost or become abnormally cold, it will give support to this theory.

While it is a far less probable explanation, the contraction of parts of certain types of ammonia piston will sometimes allow of sufficient motion to produce a pound. This is usually where the pressure of the compressed gas is allowed to enter the piston and distend a "bull ring."

It is barely possible that the crank-end clearance is so small that the contraction of the piston rod allows the piston to strike the back head until the rod gets warmed up. This can be proved by taking the clearance and by inserting a piece of solder wire behind the piston just before the crank passes the back center.

A Deserving Cause

We are advised that a fund is being raised in England, by subscription, to provide for the invalid wife and young children of the late B. H. Thwaite, who in 1894 conceived and proved that blast-furnace gas can be used in gas engines. He was no business man and he got nothing out of it. He spent all his own fortune on it and died, a broken-hearted man, in the spring of 1908.

The widow set to work at once to provide for her two young children, but was attacked with a recurrence of a sickness for which she underwent an operation three years ago. Her case is now believed to be hopeless.

Friends of Mr. Thwaite got Andrew Carnegie interested to the extent that he has agreed to subscribe £500 ($2500), provided a like sum be obtained from others.

The committee in charge of raising this fund consists of the following: H. A. Alabaster and T. E. Gatehouse, of *The Electrical Review*, London; Professor Arnold, of Sheffield; R. K. Gray, of the Indiarubber and Telegraph Construction Company, Silvertown, London; W. M. Mordey, president of the Institute of Electrical Engineers, London; Harold Jeans, *Iron and Coal Trades Review*, London; Sir William H. Preece, 8 Queen Annes Gate, S. W., London.

The secretary of the committee, to whom contributions may be sent, is W. H. Booth, 2 Queen Annes Gate, Westminster, London. Mr. Booth is well known to POWER readers.

Obituary

Kenton Chickering, vice-president of the Oil Well Supply Company, of Pittsburg, died at Oil City, Penn., December 8. He was vice-president of the company from its formation, prior to which he was for thirty-nine years connected with Eaton & Cole and the Eaton, Cole & Burnham Company.

The first annual dinner of the superintendents and foremen of the Kinkora Works of the John A. Roebling's Sons' plant was celebrated at Roebling, N. J., on the evening of Wednesday, December 23. Assembled at the tables, where an appetizing dinner was served, were nearly fifty gentlemen bent on having a good time, and they had it. Appropriate favors were distributed. T. A. Major was the toastmaster. It is the intention to repeat this social occasion each year.

The annual smoker of Brooklyn Association No. 8, N. A. S. E., was held at its meeting rooms, 315 Washington street, Brooklyn, on Saturady evening, December 19. An enjoyable entertainment was furnished by the "bunch," assisted by Henry Elder, Carl Cronlin and Charles C. Drant. During the evening addresses were made by James Westberg, R. O. Smith, Thomas Cole and Timothy Healey. Frank Martin made a genial toastmaster. Refreshments of all kinds were constantly on tap.

Business Items

A handsome wall calendar for 1909, printed to represent burnt leather, is being distributed by the Wilpaco Packing Company, 109 Liberty street, New York.

The York Manufacturing Company, York, Penn., manufacturer of ice-making and refrigerating machinery, has closed 28 recent orders aggregating 1377 tons of refrigeration.

C. P. Bassett, of Charlotte, Mich., maker of the McNaughton sectional grates, has received a letter from W. P. Engel, president of the Peoples Gas and Electric Company, Defiance, Ohio, in which he says: "I acknowledge the corn. Your boiler grates are far superior to any grate I have used. We have been using two full sets, under two 350-horsepower Heine boilers for two years and three months. The repairs have cost but $1.80 for the sectional grates. There has not been a warp or a sag in the bars, and the increase in draft is fully 25 per cent. We consider that we are saving 40 per cent, in repairs and 20 per cent. in fuel."

The Foos Gas Engine Company, Springfield, Ohio, is furnishing a producer-gas plant complete to the Standard Optical Company, for its new lens-grinding department, at Geneva, N. Y. The engine will be a 100-horsepower three-cylinder Foos vertical from which power will be transmitted by rope drive. The producer will use Pennsylvania anthracite and is so arranged that a portion of the gas will be drawn off and used for annealing furnaces. The plant will be very complete and will contribute materially to the economical operation of the factory. The Foos factory at Springfield has been working overtime for several months in the endeavor to keep up with orders.

The Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, manufacturer of the Buckeye boiler skimmer for removing impurities from the water in boilers, has received a letter from Kelsey & Freeman, of Toledo, Ohio, in which they say: "We have had your automatic skimmers in use now about six months and have given them a pretty thorough test. We formerly cleaned one boiler each week and even at that had difficulty in pulling load on account of foaming. Now the old scale is dropping off and the water in boilers is considerably more free from settlement, thus requiring less attention and giving much better results. Your skimmers have done already what you guaranteed them to do and are worth their cost to us twice over since we installed them. To anyone using water as bad as Maumee river water we cannot recommend them too highly."

New Equipment

A new power plant is being erected for the Oconee River Mills, Milledgeville, Ga.

The Shelby (N. C.) Cotton Mill is building an addition. Electric power will be used.

The city of Clearwater, Fla., has voted to issue $25,000 bonds for water works.

The Beeville (Texas) Water and Light Company will rebuild water and light plant.

Wm. E. Everheart, Maryville, Mo., will establish an ice and cold-storage plant to cost $25,000.

Independent Ice Company, Nashville, Tenn., will erect a new factory building, boiler and engine rooms.

Morris & Co., Chicago, Ill., has had plans prepared for a cold-storage plant, which will cost over $700.000,

The Atlanta (Ga.) Power Company, recently organized, proposes to establish electric-power plant.

The Bellefonte (Penn.) Electric Company is having plans prepared for dam, concrete power house, etc.

The city of Hooker, Okla., voted $20,000 bonds for construction of electric-light plant and water works.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AGENTS to sell one of the best known and widely advertised shaking grates on the market. Exclusive territory granted to anyone who can make good. Liberal commission. Perfection Grate Co., Box 1081, Springfield, Mass.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

YOUNG MECHANICAL ENGINEER, three years' experience as salesman, would like to connect with engineering house or contracting engineers. Box 82, POWER.

SALESMAN—Mechanical engineer, college graduate, 28 years old, five years' experience with large steel plant, desires salaried position as salesman handling power specialties. Preferably Pittsburg or Cleveland district. Address "F. J.," POWER.

CHIEF ENGINEER, 17 years' experience on engines, dynamos, plumbing, wiring, sewage disposal, telephones, etc. Am at present in good position, having effected saving of about 1000 tons per year. Best references; change of locality desired. Address "H." Box 80, POWER.

ENGAGEMENT DESIRED to install small, or medium-sized steam, electric or hydro-electric plant, or as chief engineer mining company in South or West preferred. Am graduate electrical engineer, experienced in mining and milling work. Can give references. At liberty February 1. Box 81, POWER.

POSITION WANTED as chief engineer; experienced with all kinds of engines, steam turbines, a.c. and d.c. generators, motors and switchboards, boilers and pumps. I can get results and furnish the references; have been seventeen years in the mechanical and engineering business. Box 9, POWER.

POSITION WANTED by a thoroughly competent and practical engineer. Long experience in erecting, installing and operating steam, water and electric power plants; capable of taking full charge of any plant. Am now holding good position under first class Massachusetts license, but desire a change. Best of references on application. Box 77, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

DRAFTSMEN—Put in a requisition for my parallel device, $2.50. F. G. Hobart, Beloit, Wis.

WANTED—Left hand, second hand Corliss engine in first class condition to develop 100 to 150 horsepower. Box 79, POWER.

IF YOU DESIRE to learn the latest improvements in steam boilers, correspond with the Detroit Water Tube Boiler Co., Detroit.

WOULD BUY ARTICLE in machine line to manufacture. If you have inventions, write, giving full descriptions. If patented give numbers. Box 78, POWER.

ENGINES AND BOILERS, ½ to 2 h.p., engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make an investigation and report if patent can be had, and exact cost.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

THE ANNUAL MEETING of the stockholders of the Hill Publishing Company, for the election of directors for the ensuing year and for the transaction of such other business as may properly come before the meeting, will be held at the office of the company, in the Hallenbeck Building, 497-505 Pearl St., Borough of Manhattan, New York City, N. Y., on Tuesday, January 26, 1909, at 12 o'clock noon. Dated, New York City, December 9, 1908. Robert McKean, Secretary.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

150 HORSE-POWER tandem compound Corliss engine, in good order; 16-ft. wheel; 24-in. face. F. W. Iredell, 11 Broadway, New York.

CHANCE TO GET A TRACK SCALE CHEAP. Fairbanks, Morse & Co., No. 4369, T. R. B. scale with dead rail, style 12, never been used. Morgan & Wright, Detroit.

FOR SALE—20x48 Wheelock engine and two 72″x18′ high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

PLANIMETERS FOR SALE—Get the mean pressure of any diagram with the simplest and best planimeter in a minute's time. Send $1 to Peter Eyermann, Consulting Engineer, Du Bois, Pa., for the planimeter and instructions.

FOR SALE—20″x42″ improved Greene engine. Wheel 32″x14′. Used seven years. Also 24″x48″ improved Greene engine. Wheel 42″x16′. Used eight years. Both engines in first class shape. Can be seen running. The Capewell Horse Nail Co., Hartford, Conn.

New Power Plant of Carnegie Institute

Designed for Appearances as well as Efficiencies, with Extensive Heating and Ventilating Systems and Unusual Metering Facilities

BY THOMAS WILSON

In looking over Pittsburg, strangers never fail to visit the far-famed Carnegie Institute. This is an immense structure occupying a ground plan of about 440x660 feet, with a total floor space of over 15 acres and representing an expenditure of $6,000,000. The building is located in Schenley park in the midst of the residential district of Pittsburg and originally consisted of the Carnegie Library building and Music Hall. In 1900 a large sum of money donated by Andrew Carnegie made it possible to make extended additions to the library and educational institute and to add museums, art galleries and a large hall of architecture and sculpture. Architecturally the building has been given every attention. It is of stone construction with an imposing exterior, and within the design and decoration are highly artistic. For the greater part it is three stories in hight, the book-stack section alone having eleven floors, and is well lighted from an unusual number of large windows. Alden & Harlow, of Pittsburg, were the architects, and Charles R. Cunningham is superintendent of the building.

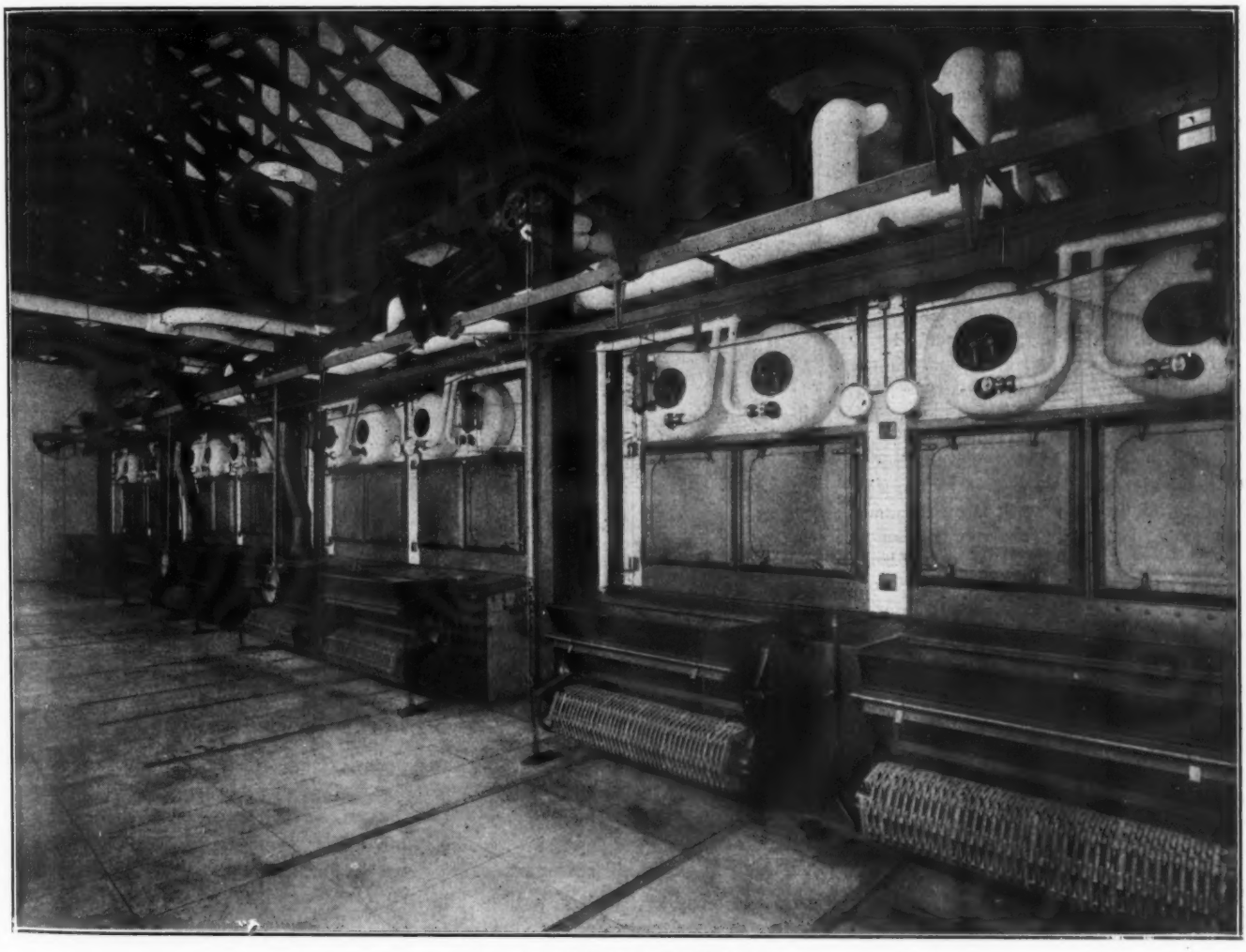


FIG. I. THE BOILER INSTALLATION

With the large extension to the institute it was necessary greatly to increase the capacity of the mechanical plant, and for reasons of economy and convenience of operation it was decided to install a plant entirely new and of sufficient capacity to serve the entire building. Every effort was made to secure the best equipment on the market, to give it the best arrangement possible from an artistic as well as an economical standpoint, and above all to make the plant as attractive as any department in the building. From the photographic illustrations it is apparent that the efforts of Mr. Cunningham were not in vain.

A building of such immense proportions required a large plant, involving the generation of electric current for light and power, heating and ventilation, refrigeration, elevator service, vacuum sweeping and the compression of air. Machinery for these various services was located in the basement of the institute, but to have a boiler room with its dirt and smoke in such near proximity to the many costly

and important exhibits in the building, was not looked upon with favor. Fortunately a deep ravine nearby offered a favorable site, and when erected but very little of the boiler plant was visible from the institute. Furthermore, one of the conditions was to design a plant which would not produce smoke, and the difficulty of connecting the two departments of the plant with steam and water piping was rendered unobjectionable by cutting a tunnel 500 feet long through solid rock to the central portion of the basement. In all 2400 horsepower of boilers have been installed and in generating equipment 2200 horsepower for supplying with current 30,000 incandescent lamps and over 500 horsepower in motors. The exhaust from these units must heat nearly 14,000,000 cubic feet of interior volume, and a large amount of live steam is required for the various pumps, ammonia compressor and other machines.

Boiler House

Part way up the ravine and about 60 feet below the grade of the institute, a level plot was blasted out of the solid rock to afford a site for the boiler house, which is a brick and steel structure 65x150 feet in plan and 58 feet from the floor to the eaves, bounded by a concrete floor and roof. The entire upper portion is given over to continuous coal bunkers of concrete, holding 8000 tons of coal, and an ash pocket with a capacity of 1000 tons. The tunnel, which is 7½ feet wide by 12 feet high, is 32 feet above the boiler-house floor, and is connected by a stairway with an extensive system of iron grating giving access to the top of the boilers and piping. From this grating stairways lead to the boiler-room floor and to the coal bunkers above. The stack is on the institute side, rising 195 feet above the boiler-room floor. It was built of radial brick by the Alphons Custodis Chimney Construction Company and has an interior diameter at the base of 9 feet.

Eight 300-horsepower Babcock & Wilcox water-tube boilers are installed and are set in four batteries of two each. The settings are spaced 6 feet apart and have been placed to allow a firing floor of 24 feet in front and a distance of 11 feet from the rear of the settings to the wall. The boilers are of the standard heavy-pressure type with two steam drums 42 inches in diameter and 23 feet long, a 12-inch cast-iron mud drum and 144 four-inch tubes 18 feet in length. The tops of the steam drums are covered with 2-inch magnesia blocks which are supported on a wire netting to allow a 2-inch air space between them and the boiler. Each boiler contains 3051 square feet of heating surface, carries a working pressure of 150 pounds and is equipped with an 8-inch delivery nozzle, two 4-inch nickel-seated safety valves set for 160 pounds and a Williams feed-water regulator and gage column.

A grate area of 52 square feet in a Greene chain-grate stoker is provided in each boiler. A water back which can be run close to the fuel bed or raised to allow clinkers to pass is in place at the rear, and with an arch a little longer than usual almost perfect combustion is obtained. Only on rare occasions is smoke visible from the top of the stack and then only a light haze, due to starting up one of the boilers or a similar reason. The stokers are eccentric-driven from a shaft beneath the floor, and this in turn is belted to two Westinghouse Junior 7-horsepower engines, one being held as a reserve. At the rear of the boilers a breeching, 37x60 inches, carries the gases toward the stack, discharging into a rectangular flue at the center 7 feet wide by 10½ feet high, the breeching increasing in size to meet these dimensions as it proceeds toward the stack. The boiler connections are 37x49 inches, and each is fitted with a balanced damper. In the flue or main connection to the stack is a set of double vertical dampers. These are mounted on ball step bearings below the casing, and are controlled by a Kieley "Climax" damper regulator.

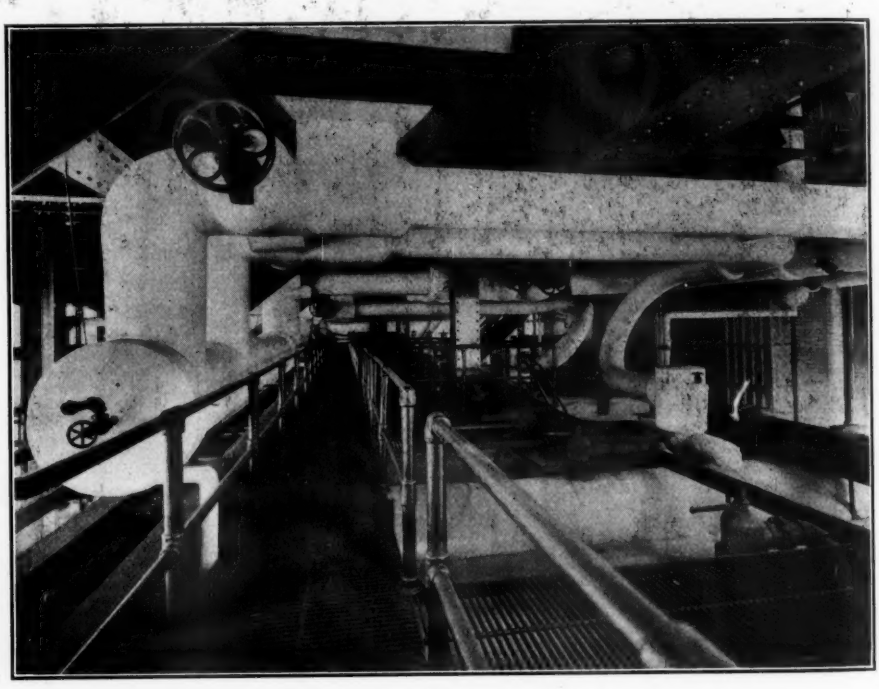


FIG. 2. PIPING AND WALKWAYS ABOVE THE BOILERS

Coal and Ash Handling

As previously stated coal is stored in bunkers of 8000 tons capacity. These are four in number and extend the entire width of the building with a 40-degree slope toward the center. Concrete walls on 30-foot centers divide the bunkers, and at the end an ash pocket of the same width and 15 feet long is located directly over the spur track carrying the coal into the boiler house. From each bunker there are two delivery spouts, one to each boiler, terminating in cutoff gates directly above a runway carrying two weighing hoppers, each of 1000 pounds capacity. These are mounted on four-wheel trucks which can be moved to any one of the eight boilers by a gear operated from the floor and the contents weighed before entering the stoker. The weighing-lever mechanisms, of Howe make, are suspended to within a convenient distance from the floor and are inclosed in "banjo" covers. Usually the scales are set at 700 pounds and coal is allowed to run into the weighing hopper until this weight is lifted. In this way the coal never overflows the hopper and a convenient amount is obtained to fill the stoker hopper.

In the ravine a spur from the Baltimore & Ohio Railroad delivers the coal to the plant, the track extending into the building and allowing the coal to be dumped directly from hopper-bottom cars into a receiving hopper below, which holds an entire carload.

Before being dumped the coal is weighed, a section of track 42 feet in length and the scale beams being suspended from steelwork above. Slack is the fuel usually burned, and in this case it is taken directly from the hopper by a McCaslin conveyer of the overlapping gravity-bucket type, which encircles the entire boiler room, running directly under the ashpits and up into a monitor above the coal bunkers, where a trip set at the desired location empties the buckets as they pass. The conveyer is driven by a 20-horsepower General Electric inclosed motor, which is located at one end of the monitor. The starting box is placed near the motor, so that it is necessary to start the machine at this point, as it is always well to look things over before setting the conveyer in operation. There is a second switch, however, in the basement near the crusher con-

trolling the motor circuit, and this may be opened at any time to stop the conveyer. If the coal is of lump size it is first passed through a McCaslin single-roll crusher, driven by a 30-horsepower General Electric inclosed motor. This machine, by means of gearing and a winch is also called into service to pull the cars from the spur into the boiler house.

From the chain grates ashes drop into steel-plate hoppers immediately below and thence through undercut gates into the buckets to be conveyed to the ash bunker above. As this is directly over the track the ashes are run into the empty cars and from these dumped through the trestlework into the ravine. It is the intention in the near future to give the ashes free passage to the ravine by means of a spout connection to the bunker, as in storing the ashes to any depth they have merged into a solid mass, causing much difficulty in their removal. With the spout arrangement there would be no need for storage, and as the demand for ash filling is great, there would be no accumulation in the ravine. With the present arrangement it is an easy matter to weigh the ashes on the car scales.

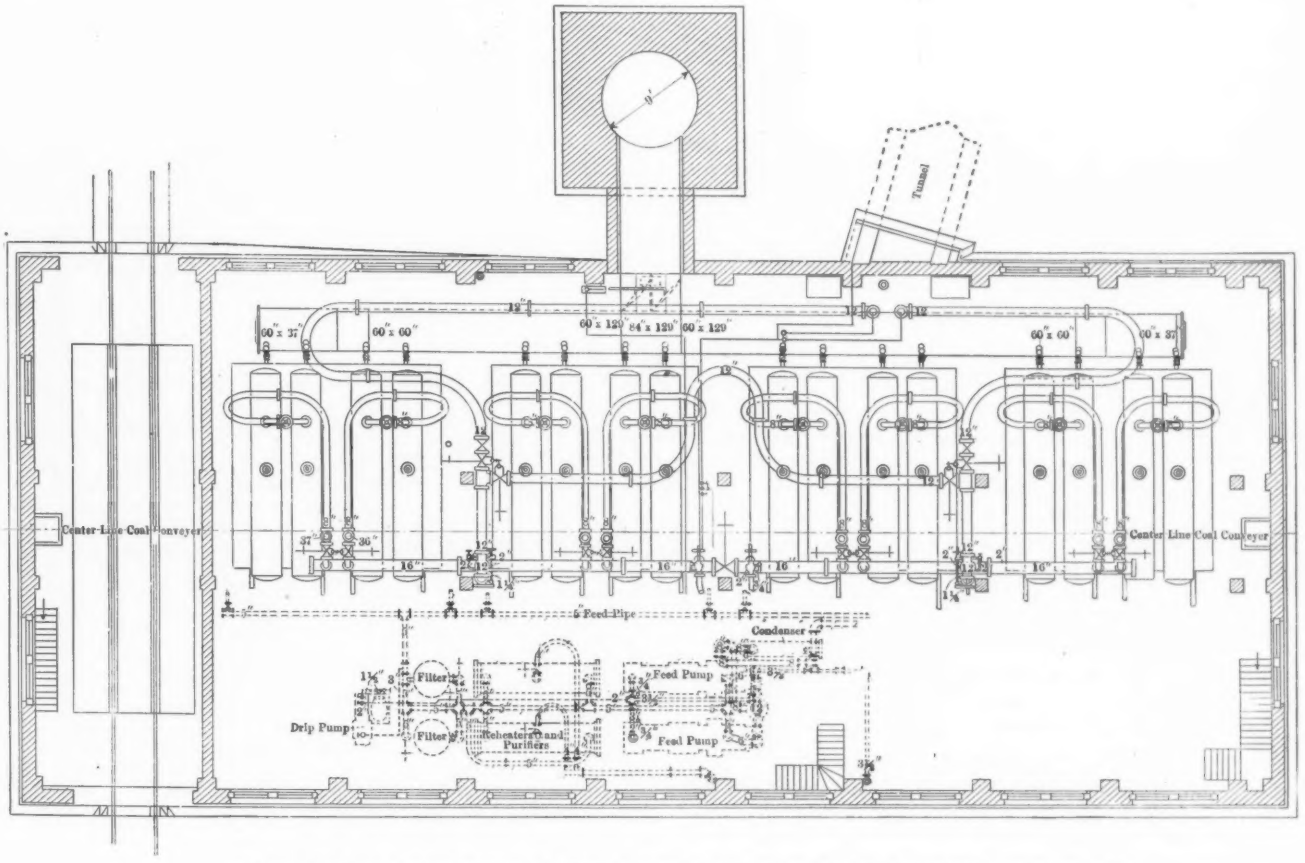


FIG. 3. PLAN OF STEAM PIPING IN BOILER HOUSE AND FEED-WATER APPARATUS IN BASEMENT

Path of the Feed Water

Most of the water for boiler feeding comes from the returns of the heating system and whatever is lacking is made up from the city mains. The condensation is collected in two Webster "Star" vacuum open feed-water heaters of 1500 horsepower capacity each. From these the water is conveyed in an 8-inch line through the tunnel to the boiler house, dropping vertically to the basement and first connecting to a Wainwright surface condenser, with bypass connections, and thence to a special air chamber and continuing to the pumps through 6-inch branches.

Steam from the pumps in the boiler house and the stoker engines is passed through the Wainwright condenser and utilized to increase the temperature of the feed water. The condenser is 4 feet in length, 18 inches in diameter and contains thirty-six 1½-inch corrugated-copper tubes 36 inches long. It is built to withstand a working pressure of 125 pounds. The air chamber is a 12-inch pipe, 10 feet high, in which the water enters at the bottom and is taken off 3½ feet above. The top is capped with a blank flange, and the 6½ feet above the outlet is the air chamber.

The two pumps are of the Wilson-Snyder outside-packed plunger pattern, 8x14x8x18 inches, and both suctions and discharges are cross-connected, so that the pumps may be readily interchanged. From the pumps the water next passes to a Gunning reheater and purifier and then to a Gunning filter and thence through a Worthington meter to be measured. There are two sets of Gunning filter and reheater, each of 1200 horsepower capacity, and by the use of live steam at boiler pressure the outfits are capable of raising the feed water to 310 degrees Fahrenheit, at the same time removing much of the scale-forming ingredients contained in the water. The reheaters are steel tanks 40 inches in diameter, 15 feet long and containing 800 feet of 1⅞-inch copper tubing, while the filters are 15 inches in diameter by 8½ feet high. The reheaters were built to withstand a pressure of 160 pounds, but at the present writing are out of commission on account of leaks, and grave doubts are expressed by the management as to the advisability of using live steam to secure this additional 100 degrees in the feed water. Consequently the reheaters are bypassed and the water forced to the boilers through a common 5-inch copper main running under the boiler-room floor. From the main a 2-inch brass pipe carries the water to each boiler, passing on its way up through a graduating valve and a combination check and stop valve at the boiler connection.

Two blowoff connections are made to each boiler, each 2½ inches in diameter and connecting at opposite ends of the mud drum. All the connections tap into a common 4-inch main leading to a receiving tank 4 feet in diameter by 12 feet long at the rear of the basement. This tank receives the dirty drips as well as the boiler waste, and is provided with 238

feet of 2-inch brass piping to cool the water before discharging it to the sewer. The overflow to the sewer is at a point 8 inches from the top of the tank, which is always nearly full of water and will tend to cool additional water as it is received. A 4-inch connection leading to an exhaust head above the roof allows the steam and vapor to escape.

Boiler Piping

Owing to the size of the plant and the distance between the boiler and engine rooms, an elaborate system of piping has been arranged to carry the steam from one department to the other. The arrangement of this piping is shown in the plan views, Figs. 3 and 7. Primarily the system consists of a large main header in the boiler room, which is connected to a large distributing header in the engine-room basement by two 12-inch mains running through the tunnel and measuring nearly 600 feet in length. The main header in the boiler room is 16 inches in diameter, 93 feet long, and near the front edge of the boilers is carried on roller supports. Leaders 8 inches in diameter connect the boilers to the header, and to provide for expansion these are turned in long radius bends, as shown in Fig. 3. Each leader is provided with a Chapman nonreturn stop and check valve. At the center the main header is sectionalized by a stop valve, and to each half are connected four boilers and one of the 12-inch delivery lines. The supply lines are cross-connected, so that either set of four boilers may supply either line, and at the center of this connection expansion is provided for by the U-bend shown in the drawing.

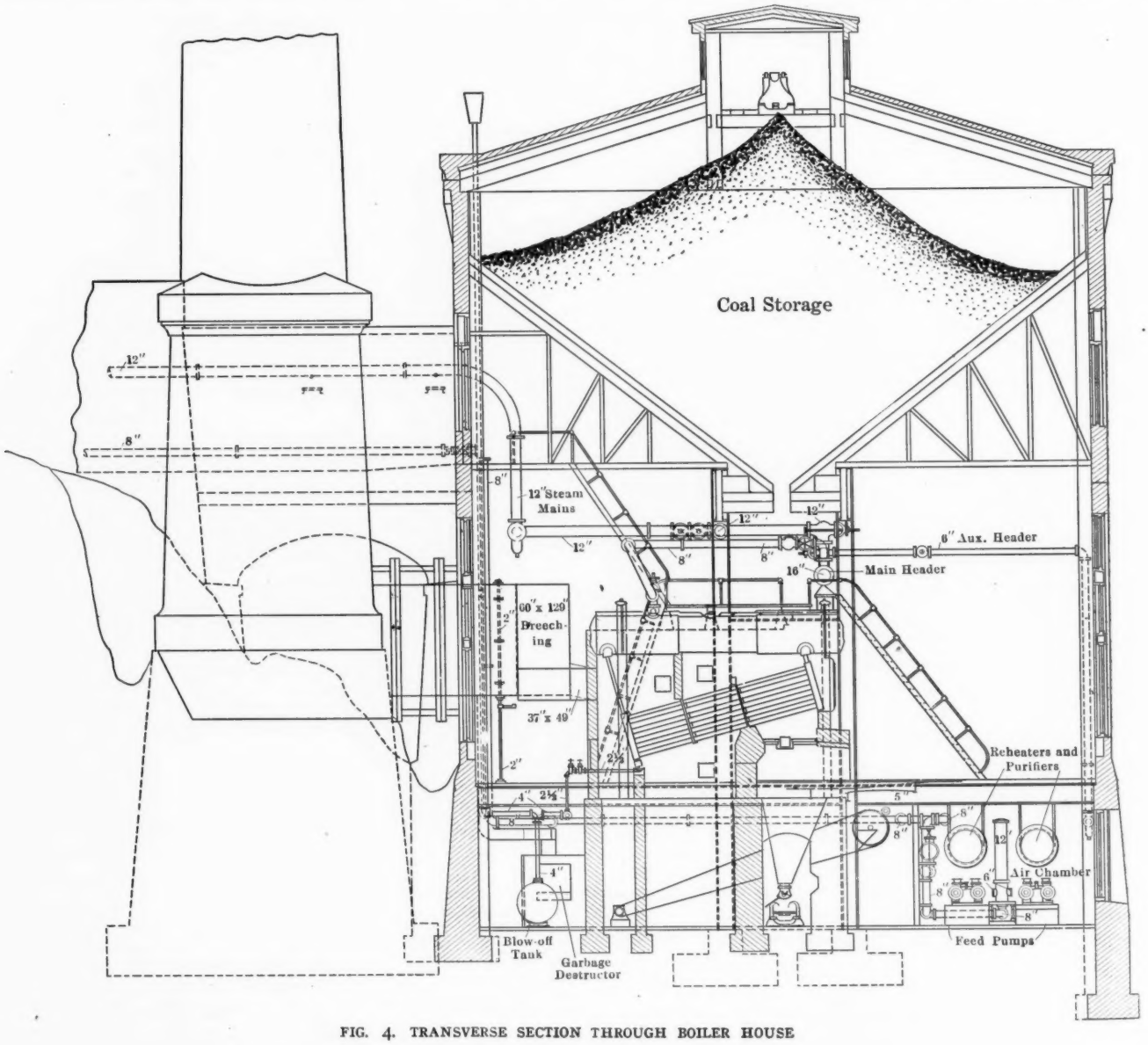


FIG. 4. TRANSVERSE SECTION THROUGH BOILER HOUSE

Each of the supply lines is equipped with motor-operated valves, and these may be controlled from five different places on the engine-room side of the tunnel. Three of these points are in the engine room, one in the engineer's office and one in the pump room. At each control point is a panel carrying three push buttons and three colored miniature lamps; one button starts the motor to open the valve, another button stops the motor, and a third button starts the motor in the opposite direction to close the valve. A red light in connection with the first button shows the valve opening, a white light shows that the motor is running, and the blue light shows the valve closed. After a few trials it is an easy matter to tell the approximate position of the valve, and the control panels are often tried out to show that they are in working order. There is also provision to close the valves by hand in the boiler room. With this arrangement the valves may be readily closed at either end and much trouble averted if a supply line should accidentally burst in the tunnel. The Chapman Valve Manufacturing Company designed this equipment.

The auxiliary header shown in Fig. 4 is 6 inches in diameter and was designed to supply all steam required in the boiler house. It has connections to the

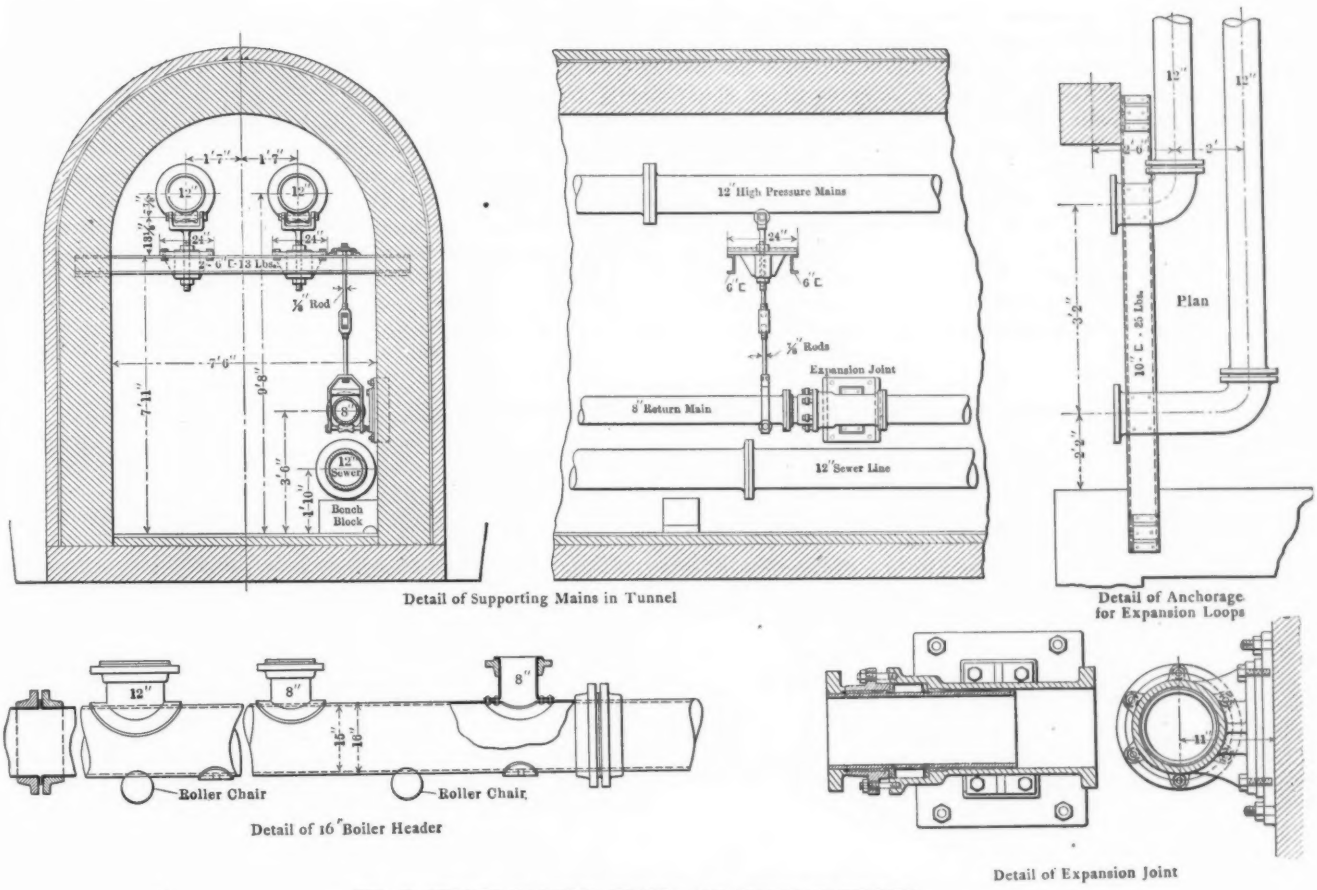
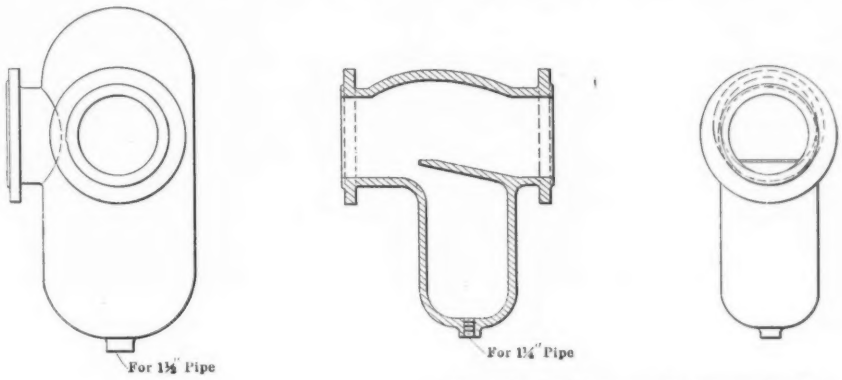


FIG. 5. DETAILS OF BOILER HEADER AND PIPING IN TUNNEL

main header on either side of the sectionalizing valve, and extends from the front of the boilers to the wall, where it drops to the basement to supply the auxiliary equipment.

The 12-inch supply lines are connected to the top of the main header and from angle valves run horizontally to the rear with long, sweeping bends and return to points in line with the tunnel. Here drip pockets are provided and the mains rise vertically 15½ feet to enter the tunnel, and at the entrance are bent on a 6-foot radius. In the tunnel their arrangement and method of support is shown in Fig. 5. The two supply mains occupy the arch of the tunnel and at points 12 feet apart are supported by 6-inch channels running transversely across the tunnel and imbedded in the masonry. The channels are 24 inches apart and between carry a block supporting an 8-inch roller conforming to the shape of the pipe. This roller is carried in trunnions on the upper ends of screw rods which pass vertically through the block and are adjusted by nuts above and below. At a bend in the tunnel near the center point the mains are rigidly anchored to the tunnel wall, so that expansion may occur in either direction. Toward the engine room expansion is provided for by U-loops extending horizontally and at right angles for a distance of 20 feet, and as the mains are rigidly anchored in the engine-room basement by means of a 10-inch channel attached to the steel work of the building, all expansion or contraction must be taken up by the U-loops.



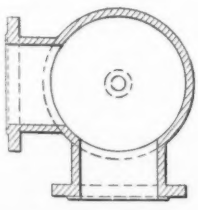


FIG. 6. DRIP-LEG TEES USED IN STEAM PIPING

Ample provision has been made for draining the mains. There is a drip leg at the bottom of the vertical rising from the boiler room to the tunnel, another at the center of the tunnel, and a third at the expansion loop near the engine room. The first two drips mentioned and those in connection with the main header in the boiler room are taken by a Wilson-Snyder 7½x4½x6-inch duplex drip pump and discharged to the suction side of the boiler-feed pumps. The condensation from the expansion loops enters the engine-room system of drips.

In the tunnel there are two other mains, one an 8-inch return from the Webster heaters and the other a 12-inch sewer line. The former is hung from the supply-main channels by means of a rod provided with a turnbuckle, so that its elevation may be readily varied, while the sewer line is carried on bench blocks upheld by the tunnel floor.

It may be of interest to note that the tunnel is 7½ feet wide, 12 feet high to the

crown of the arch, and from the engine room to the boiler-house wall has a total length of 410 feet. About 60 feet from the boiler house the tunnel emerges from the side of the ravine, and for the remainder of the distance is carried above ground resting on a heavy concrete arch where the sloping bank of the ravine necessitates.

Engine Room

In this department every effort has been made to secure a sightly appearance. Every little detail has been given attention, and the result is an engine room of surpassing beauty. The room is 45 feet 7 inches wide by 106 feet long, and has a clear head room of 24 feet. The engine-room floor is at a level 40 feet below the main floor of the building, and the location is such as to secure an abundance of daylight from a large open court. The generating units are spaced uniformly throughout the length of the room, and at one end is a gallery floor 11 feet wide and 13 feet above the engine-room floor. Looking from this gallery nothing but the generating units and switchboard are visible. There is no auxiliary apparatus in the room, not a pipe is visible above the engine-room floor, and the cables are all concealed, including even the main generator cables, which enter the bottom of the flywheel pit and make connections at the bottom of the generator frame. Even in this pit a pier is built to within 18 inches of the generator frame to conceal as much of the cables as possible. The switchboard is all of white marble, and there is nothing to suggest electrical connections, except the switches and the instruments on the front of the board. The floor is laid with marble and on the walls a wainscoting of white-enameled terra cotta rises to a hight of 11 feet. The gallery is similarly finished, and in front is inclosed by a handsome brass railing. Five structural columns of the building are also covered with the white-enameled terra cotta, and the walls above the terra cotta are tinted. The ceiling is paneled and around the border is studded with glazed incandescents, so that the room, minus the machinery, might readily be mistaken for an elegant banquet hall.

To give the machines a setting, both the engines and generators are raised from the floor and rest on 8-inch capstones. Brass railings inclose the flywheels and generators, the floor stands to operate the throttle valves are polished, as is also the valve gear, and the small oil piping to the bearings and cylinders is nickel-plated. Gold trimmings on both engines and generators add to the attractiveness of the machines, and the oil stands seen in the photograph have been specially designed for the plant and are made of highly polished brass. The combined effect of all these little features is most pleasing to the eye, and the universal verdict of visitors to the plant would in all probability

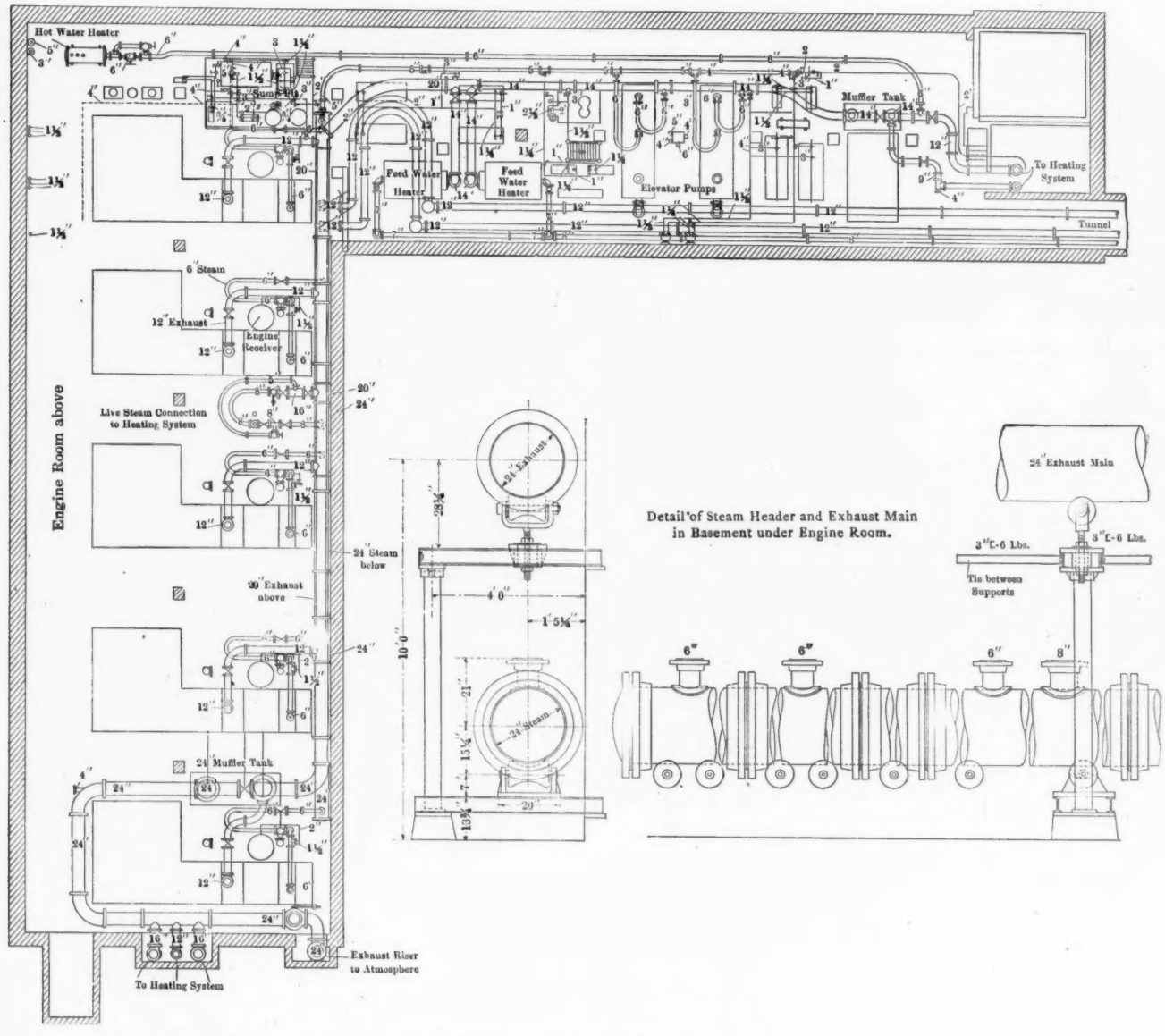


FIG. 7. PLAN OF PIPE CELLAR AND ELL EXTENSION AND STEAM AND EXHAUST HEADER DETAIL

be, "the most attractive engine room in the country."

This neatness and the extreme care of detail has not been limited to the engine room. In the tunnel the floor, walls and pipes are washed, and even the tops of the boilers and the steam piping above are cleaned at regular intervals. By no possibility must a piece of coal or a little ash be allowed to remain on the floor, and a can of grease or anything at all unsightly "dare not show its face." Even the firing tools are all concealed in a case provided for the purpose. This extreme cleanliness has made even the boiler room just as attractive to lady visitors as the art galleries or museums, and in going through the building, instead of receiving their last visit, it is usually the first place they go to.

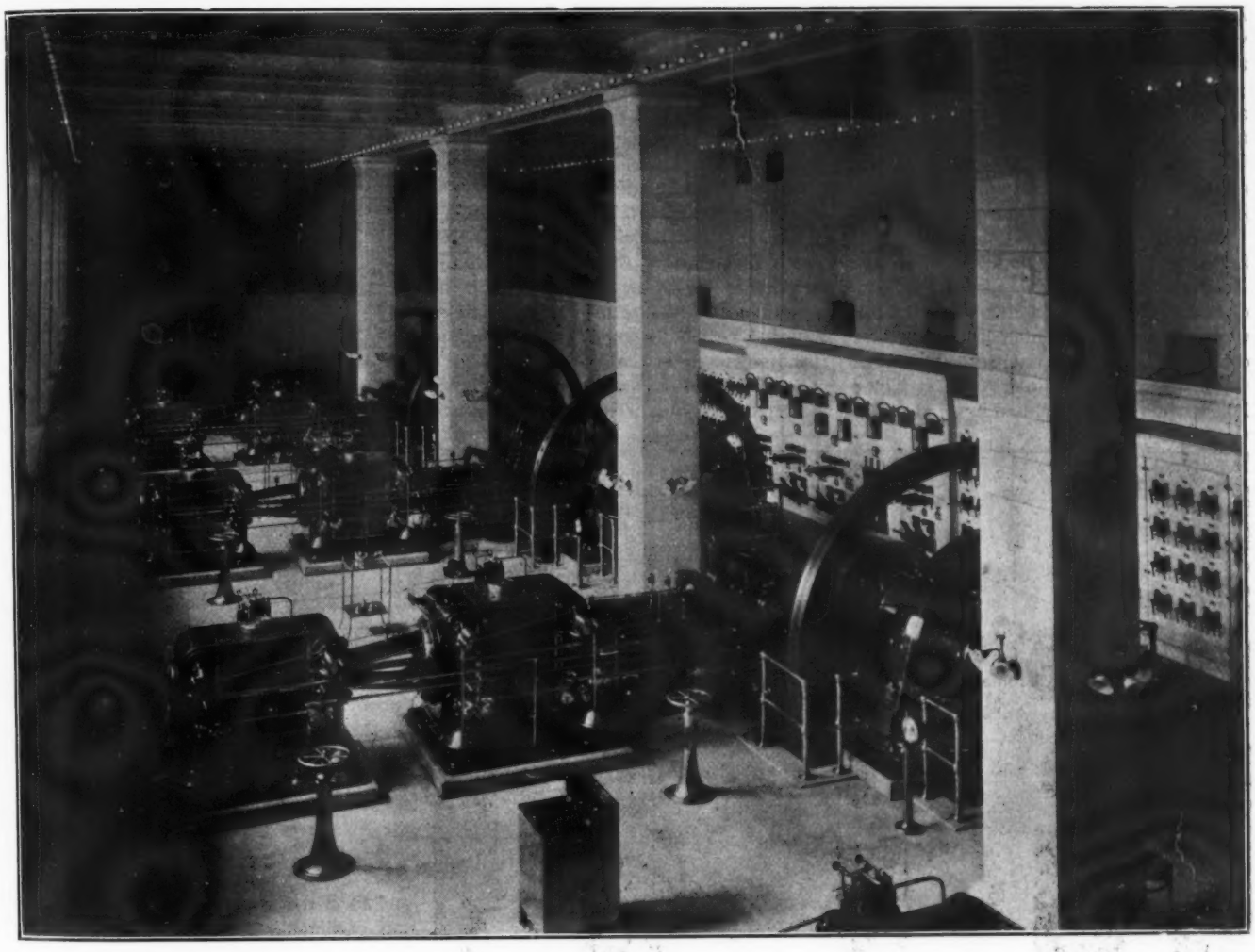


FIG. 8. ENGINE ROOM

The equipment of the engine room is five Rice & Sargent tandem compound engines, 18x26x36 inches. As is usual in the tandem compounds of this make, a third eccentric is provided, so that the valves may be operated by direct eccentric movement and no wristplates employed. One eccentric works all four steam valves, and each of the other two a pair of exhaust valves, so that the exhaust from each cylinder is controlled independently. A Rites centrifugal-inertia governor controls the speed. Richardson sight-feed oilers are provided for cylinder lubrication, and Lunkenheimer oil hand pumps are provided for emergency. A Schaeffer & Budenberg tachometer mounted on a floor stand and belted to the main shaft indicates the speed of the engines, which normally is 120 revolutions per minute. A Monarch speed limit, set for 130 revolutions per minute, is included in the equipment, and a Monarch engine stop is connected with each throttle. The stop is operated electrically at three different points, a push button being provided at the engine-room door, one on the column near the engine and still another on the switchboard. In addition the stop is automatically operated by the governor, and by means of a lever on the floor stand can be cut out for the time being and the throttle closed by hand. It is the usual practice to shut down by means of the engine stop, alternately using the different points of control to insure that the system is always in working order. Four seconds is the time taken to close the throttle, and the closing within this time was demonstrated on different occasions for the writer's benefit.

Lubrication is effected by the gravity system. The oil from the crank pit is drained to a set of Bonar oil filters, and to prevent any oil from dripping to the engine base or the floor, the crosshead guides are similarly drained to a smaller set of filters of the same make. The oil is elevated by small pumps to a tank above the engine room, and provision is made for the usual gravity flow, the connection to the bearings and various points on the engine units being made by means of nickel-plated piping brought up through the engine-room floor.

Electrical Equipment

To the engines 300-kilowatt National Electric generators are direct-coupled. These deliver 2400 amperes at 125 volts and operate in parallel to carry the load. The switchboard, which is located near the wall and is inclosed at the ends, has 15 panels: five for the generators which are located at the center of the board and five feeder panels on either side. The entire front is of white Italian marble, and as special pains have been taken to space the instruments and switches, the board has an unusually attractive appearance. The generator panels project some 6 inches from the feeder panels, and heavy cornice running the entire length of

the board and a base raising the panels about 8 inches from the floor add to the appearance of the board. Each generator panel is equipped with a Weston ammeter and voltmeter and a recording ammeter made by the French firm, Chauvin & Arnoux, of Paris; a circuit breaker on each side and the main knife switch for the generators. On No. 3 generator panel there is also a recording voltmeter of French make. The feeder panels show nothing but I. T. E. circuit breakers controlling the various circuits of the building, which are all two-wire. These circuits are further protected by Noark inclosed fuses at the back of the board and are provided with an electromagnet, which in connection with an annunciator board will immediately show, in the event of trouble, whatever circuit is out.

At the end of the engine room there is also a meter board of white marble containing 14 Standard brass-cased gages for indicating pressures of ammonia, air, steam and water, the steam gages indicating both boiler and heating pressures.

In addition to these instruments, there is a handsome recording board in the superintendent's office, some 200 feet distant. This contains five Whitney column-type recording ammeters, one for each generator, and one recording voltmeter made by Chauvin & Arnoux. These instruments are all inclosed in square glass cases resting on a marble base supported by brackets. In the space below these meters are some Standard pressure gages, one to indicate the pressure of the heating supply, another the pressure of the heating returns, a third to indicate the water pressure for elevator service and still another to show the air pressure for the Johnson system of temperature control. There is also a Dibble telethermometer to record the temperatures in the music hall 350 feet away, and a Queen & Co. telemanometer for recording the boiler pressure, and in addition a recording instrument to show the length of time each generating unit is on.

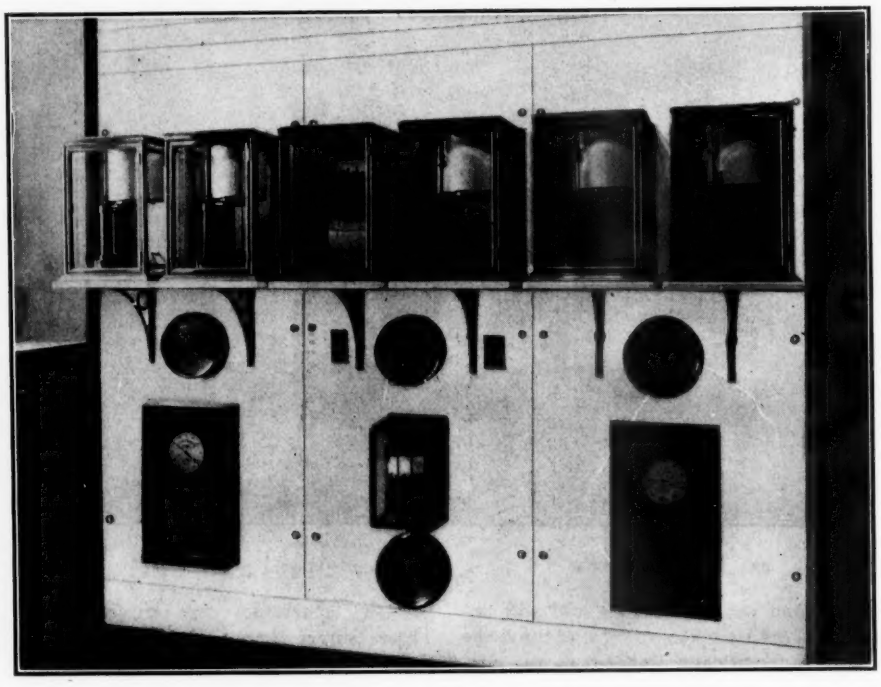


FIG. 9. RECORDING BOARD IN SUPERINTENDENT'S OFFICE

Both the French and Whitney meters are handled by Machado & Roller, of New York City, and were furnished on account of their accuracy and the small amount of current required to operate them. The French instruments are of the d'Arsonval type, equipped with mechanism of unusual size so that the torque is unusually large when compared to the friction of the pencil. The Whitney instruments are operated from the same shunt as the French recording ammeters in the engine room, that is, the two recording ammeters for each machine are operated in parallel, and the Whitney instruments at a distance of 200 feet from the shunt.

The operation of the Whitney meters is somewhat unusual, but broadly speaking, the principle on which the meter is based consists in causing the variations in the current to be measured to control the variations in pressure of a body of air in a closed vessel, these variations being in turn indicated by the rise and fall of a column of oil of comparatively large diameter, carrying a hollow float which supports the recording pen at its extremity. The chart drum is rotated 1 inch an hour by internally placed clockwork. The pen has a stroke of 6 inches and the drum a circumference of 24 inches. Fig. 10 shows the construction of the meter, and its operation may be explained as follows:

Air at a fairly constant pressure of about 1¾ pounds to the square inch is delivered to the pipe *A*, enters the chamber *B* and then flows through a series of porous diaphragms made of filter paper, whose prime function is to serve as an air resistance and incidentally to remove any dust particles. The air then enters the passage *D*, into which is drilled the opening *E* capped by the valve *F*. This valve

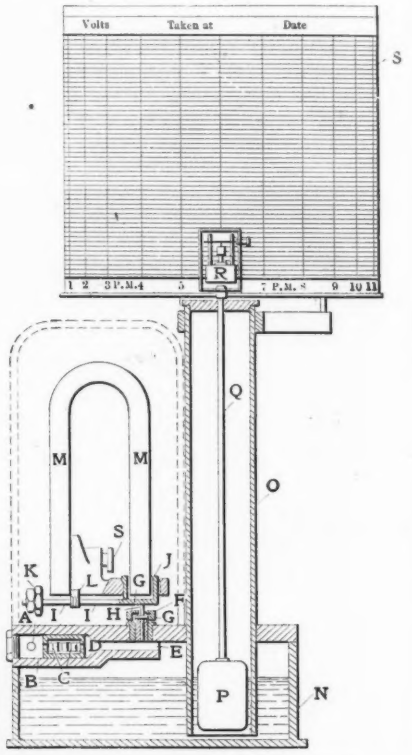


FIG. 10. CONSTRUCTION OF COLUMN TYPE METER

is a small flat disk resting on a circular seat with escape ports *G* below it and a pin *H* resting on top. On the pin rests a spool *J* carried on one end of the lever *I*, on the other end of which is the counterweight *K* by means of which the effective weight on the pin *H* can be adjusted. The spool is wound with wire through which the current to be measured is passed, this being done by means of the two thin, short copper ligaments *L* which support and form the pivots about which the lever can oscillate. A magnet *M* furnishes a field of force of such strength that the reaction between it and the current forces the spool down, with a force increasing as the current increases. The valve *F* is thus a variable-loaded safety valve whose blowing-off point is constantly and proportionately varied by the current variation. The counterweight *K* on the lever is so adjusted that when no current is passing through the spool, the weight on the valve pin is such as to give a zero reading on the scale. The air pressure cannot give a higher reading, as any tendency to increase simply results in lifting the valve slightly higher, whereupon more air escapes and the pressure falls back, and *vice versa* with the opposite condi-

tion, due to the constant flow of air from the high-pressure supply at *A*. The total motion of the spool is less than a hundredth of an inch, and the only work that the varying current has to perform is to control the air pressure. The actual energy required to move the liquid and to show the variation in current readings being supplied by an independent source. With these conditions, the instrument is extremely accurate and a drop of from 20 to 25 millivolts for full scale indication is all that the meters require.

Steam Supply and Exhaust

Below the engine room there is a pipe cellar and an ell extension which afford ample space for all the piping connections. In this cellar is located the 24-inch steam header and receiver which connects to the expansion loops at the end of the 12-inch supply mains and supplies all live steam used in this division of the plant. The header is 110 feet long and is supported 3 feet above the floor on roller blocks. Each engine is fed by a 6-inch branch taken from the top of the header and carried up with a long radius bend to a gate valve, which is operated by hand, and thence through a return loop to the throttle valve, which is controlled from the floor stand in the engine room and in nearly all cases is operated by the Monarch system of engine-stops. As the lines to the engines rise from the top of the header, no separators are required, and from each a 2-inch connection is made to the engine receiver for reheating purposes. To all the auxiliary equipment steam is supplied by a 5-inch branch, to which six lines are tapped to supply the various units. To the elevator pumps there are two 3-inch connections, another 3-inch to the two smaller elevator pumps, two 2½-inch pipes to the vacuum pumps and ammonia compressor, and a 2-inch tap extending to the drip-receiver pump and the two small pumps for oil circulation. There is an 8-inch connection to the main header to supply live steam to the heating system. The connection to the heating mains is made through two pressure-reducing valves in tandem; usually live steam is not necessary, but this provision has been made so that in the case of extreme weather the boilers may be called into service to supply the demands of the heating system.

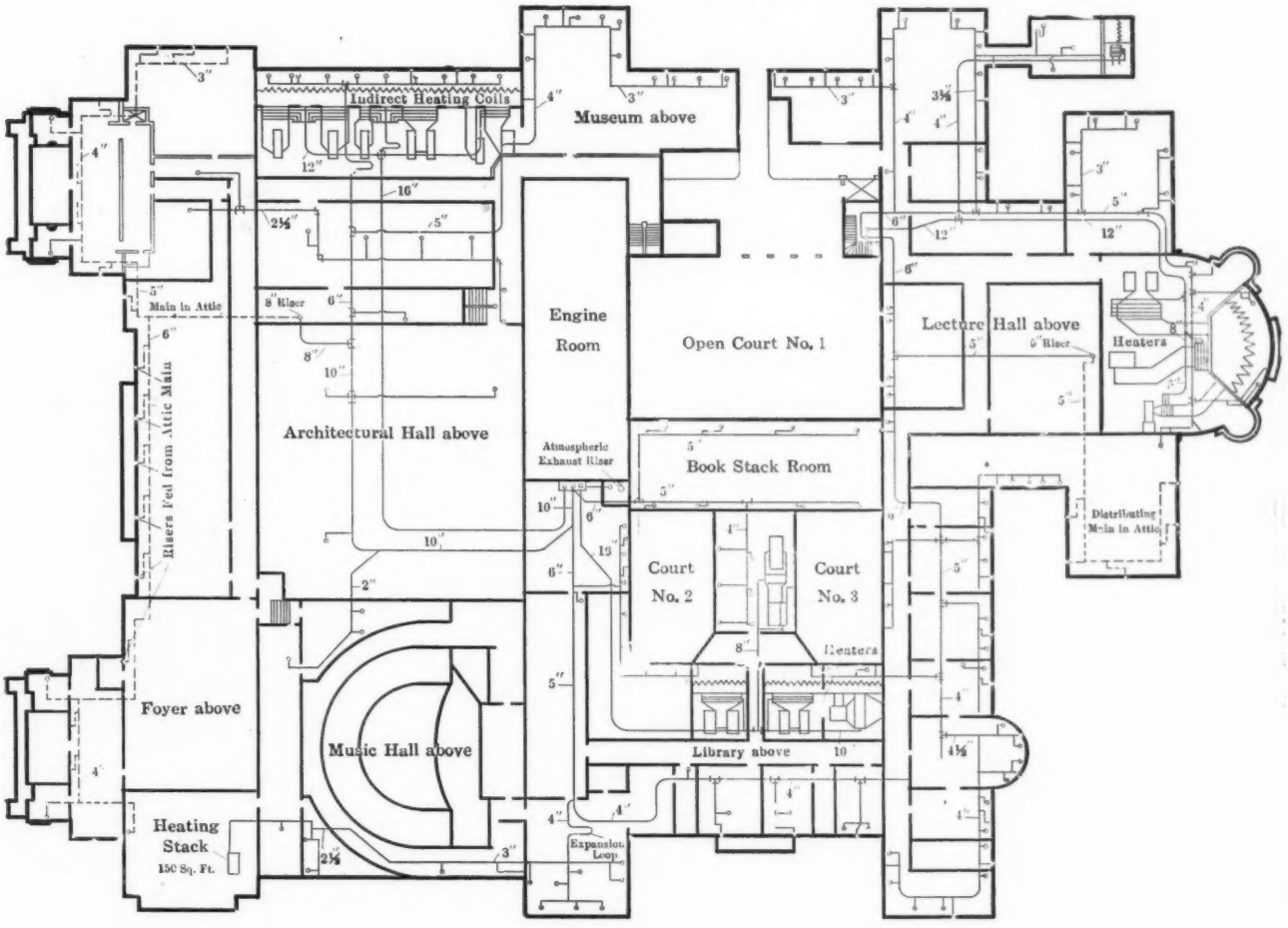


FIG. 11. GENERAL OUTLINE OF HEATING SYSTEM

Exhaust from all the steam-using machinery is collected in a common main serving as the low-pressure supply to the heating system. The main is supported above the steam header in much the same way as the supply lines in the tunnel. In the ell extension to the pipe cellar it is 14 inches in diameter, increases to 20 inches as it enters the engine room, and again to 24 inches toward the west end of the room. Each of the engine units is provided with a 12-inch exhaust, two 6-inch mains connect the large elevator pumps to the exhaust main and a number of smaller connections to the 14-inch end of the line relieves the remaining equipment of exhaust steam.

From both the 14-inch and 24-inch ends of the exhaust main, delivery is made to the heating system through Utility combined grease extractors and muffler tanks. On the large end of the main the muffler tank is 5 feet in diameter by 14 feet long, and from a continuation of the 24-inch main past the muffler, two 16-inch and one 12-inch heating mains are taken off, and beyond this the exhaust may escape to atmosphere through a Kieley back-pressure valve into a 24-inch exhaust riser. At the smaller end of the exhaust main the muffler tank is 4 feet in diameter by 9 feet long, and from this tank connections are made to a 9-inch and a 12-inch heating main, and also to a 6-inch line supplying a hot-water heater. At the end of the 20-inch section of the exhaust main two 14-inch connections are made to the Webster heaters located in the ell extension. The system of piping just described is thoroughly dripped by means of traps which discharge to the sewer,

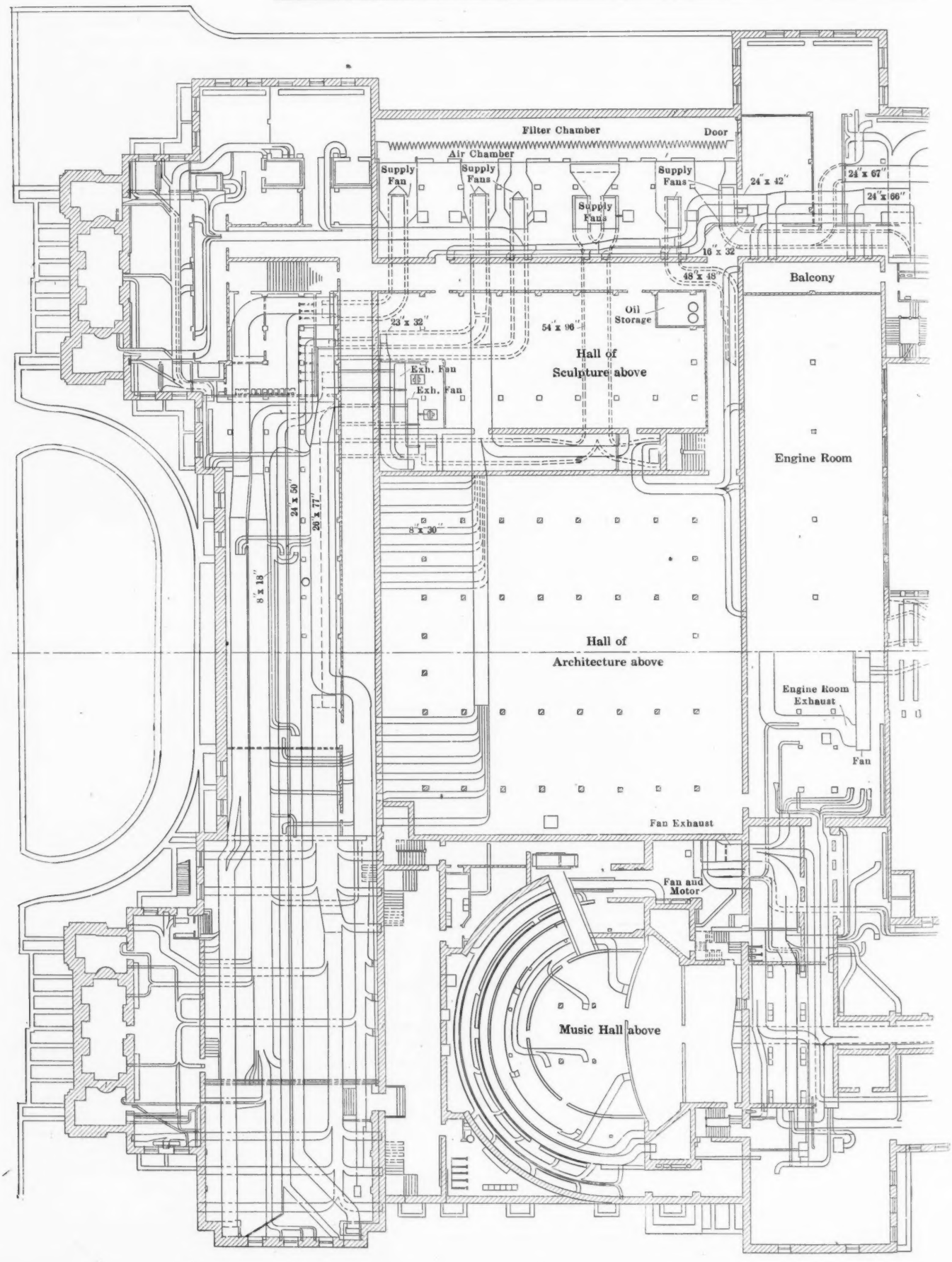


FIG. 12. VENTILATING SYSTEM IN LEFT HALF OF BASEMENT

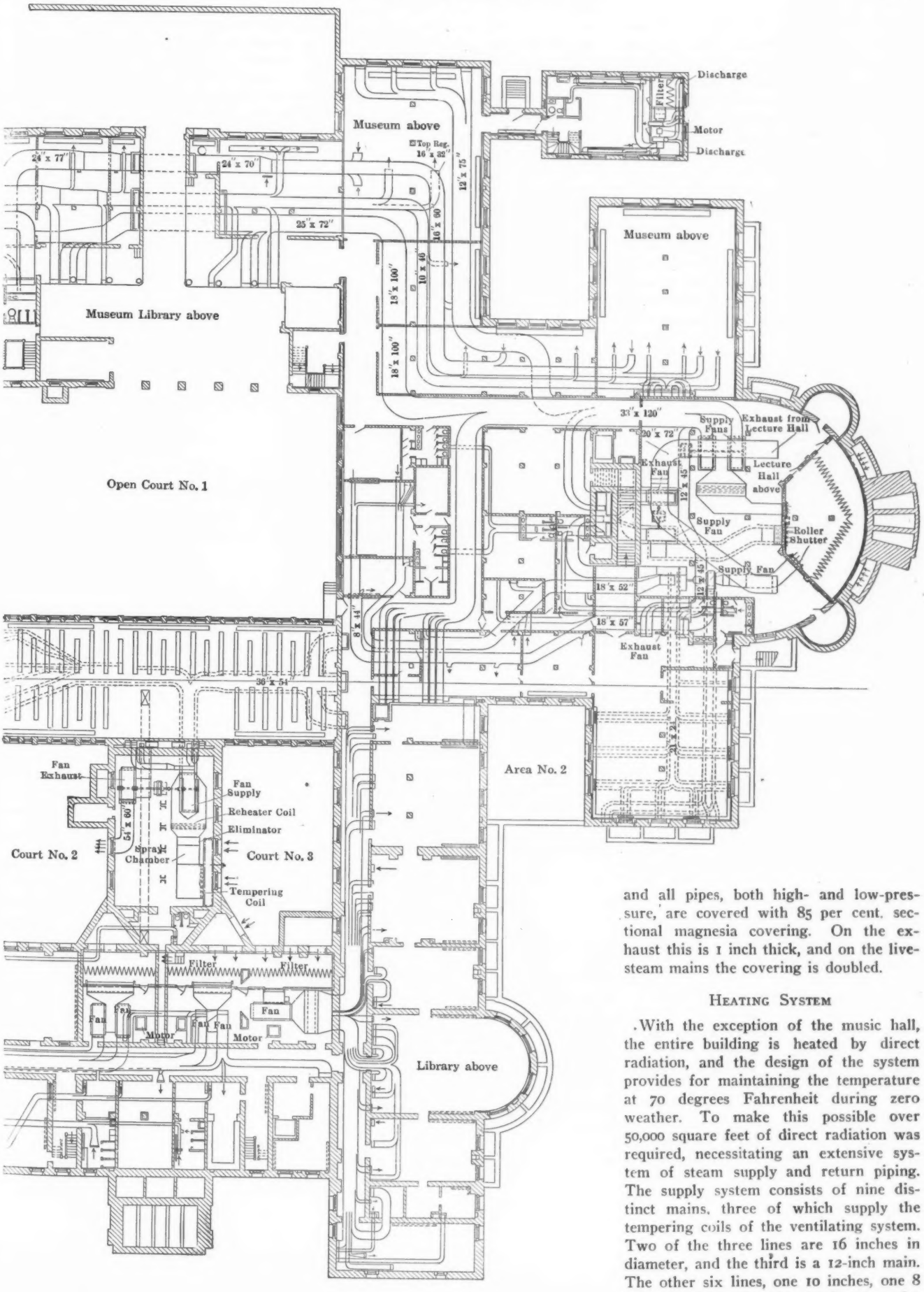


FIG. 13. VENTILATING SYSTEM IN RIGHT HALF OF BASEMENT

and all pipes, both high- and low-pressure, are covered with 85 per cent. sectional magnesia covering. On the exhaust this is 1 inch thick, and on the live-steam mains the covering is doubled.

Heating System

With the exception of the music hall, the entire building is heated by direct radiation, and the design of the system provides for maintaining the temperature at 70 degrees Fahrenheit during zero weather. To make this possible over 50,000 square feet of direct radiation was required, necessitating an extensive system of steam supply and return piping. The supply system consists of nine distinct mains, three of which supply the tempering coils of the ventilating system. Two of the three lines are 16 inches in diameter, and the third is a 12-inch main. The other six lines, one 10 inches, one 8 inches and four 6 inches in diameter, deliver the exhaust steam to the distributing

mains which supply the risers to all parts of the building. The supply and distributing mains are suspended from the ceiling of the basement, and all are properly dripped, covered with magnesia pipe insulation, and ample provision has been made for expansion.

In all, 116 risers supply steam to over 36,000 square feet of radiation upon the upper floors, which is subdivided into units, varying from 42 to 972 square feet each. The risers vary in size from 1¼ to 2½ inches and are all drained at their lower ends. The pipes are anchored at the base, expansion upward is provided for, and all are concealed in chases in the walls, branch connections to the radiators being made in nearly all cases under the floors. Throughout the building the supply mains are paralleled by the returns, of which there are 114 returning to a header in the engine-room subbasement. All but nine of these return lines are ¾ inch in diameter; four of the nine are 1-inch pipes and five are 1¼ inches in diameter.

Bundy standard radiators, fitted with Jenkins radiator valves on the supply and Webster thermostatic release valves on the return end, are installed throughout the building. In some of the larger rooms Bundy circular radiators are used, this type being preferred when the side walls were required for exhibiting works of art. Radiators up to 40 square feet of heating surface are supplied with steam by ¾-inch pipes, from 40 to 90 square feet by 1-inch pipes, and from the latter size up to 250 square feet the pipes gradually increase in diameter, in proportion with the radiating surface, up to 1½ inches. Above this limit 2-inch supply connections are made. Up to the limit of 250 square feet of radiating surface, the returns are all ½-inch, and radiators larger than this are fitted with ¾-inch return connections.

The radiation is all operated on the Webster vacuum system, and from the return header in the engine-room subbasement the air and condensation is pumped by a duplicate set of Knowles 8x14x16-inch vacuum pumps to a 3x6-foot steelplate air-separating tank, which is provided with a 4-inch vapor connection to the roof. From here the condensation flows by gravity to the Webster open heaters, of which there are two, rated at 1500 horsepower each. From the heaters the condensation is taken as boiler feed and carried to the boiler room, as previously described.

All radiating surface is controlled by the Johnson system of temperature regulation; 333 thermostats of the Johnson pneumatic type are installed throughout the building, and these control a total number of 646 heat sources. In a large number of the smaller rooms a single thermostat controls all the radiators provided for their heating, while in the larger rooms a few thermostats control a large group of radiators, and are so placed as to secure the average temperatures of the rooms. Pneumatic pressure for the thermostats is supplied at 15 pounds pressure by a duplicate set of Marsh compressors in the pump room. A feature in the installation of thermostatic control was introduced in the form of push buttons to regulate the skylight radiation.

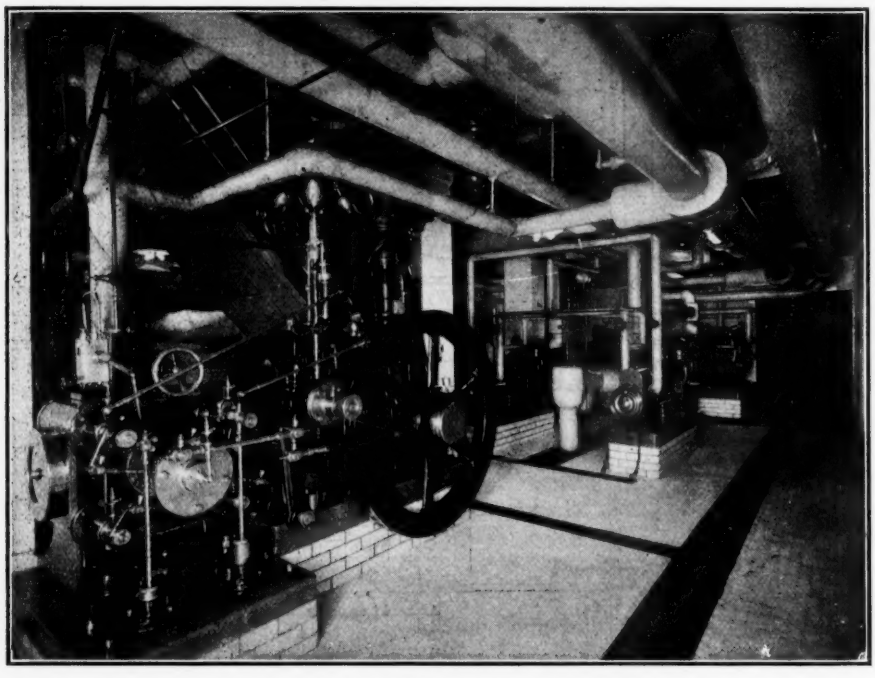


FIG. 14. AMMONIA COMPRESSOR IN PUMP ROOM

Ventilation

The entire building is ventilated mechanically, and the installation of fans required to supply the fresh air and exhaust the foul air is one of the largest ever placed in a single building. The supply fans have a capacity of over 600,000 cubic feet of free air per minute, and the exhaust fans a capacity slightly greater. For convenience, the fresh-air apparatus is arranged in 15 stations, containing in all 19 fans, and the exhaust equipment in 21 stations containing 30 fans. The equipment is Sturtevant, driven by C. & C. direct-current motors of the slow-speed multipolar type. The motors are direct connected to the fans and may be varied by field control from two-thirds to full speed. The fan wheels vary in diameter from 2½ to 10 feet, depending upon the service required.

For convenience in making duct connections the 19 centrifugal blowers are arranged in three general divisions: the first division including Systems 1 to 6; the second, Systems 7, 8 and 10, and the third, Systems 9, 11, 12 and 13. Even in this case some of the connections are 500 feet in length, but on the whole a convenient installation has been secured. In the first division all the fans have a common intake from a large continuous air filter, which is provided with fresh air from nine large outer windows. Within the intakes and between the filtering chamber and the fans are tempering coils, which, like the direct radiation, are controlled by thermostats. The air filters are of the usual cheesecloth type, with frames mounted in racks zigzagged to secure the maximum area of filtering surface. The areas of the filters for the different divisions are proportioned for velocities of 30 to 45 feet per minute.

For System 9 an air-washing equipment was provided instead of the usual type of filter. This consists of a spray chamber, an eliminator to separate the particles of water from the air and two sets of tempering coils: one to raise the temperature of the air above the freezing point in very cold weather, and the other for tempering the air the desired amount. The spray chamber consists of a system of piping, with a series of nozzles in staggered rows, which spread out the water in a thin sheet perpendicular to the direction of flow, and with the nozzles distributed in this manner a continuous sheet of water is provided for the air to pass through, which it does in this particular installation at a velocity of 10 feet per second. The water from the nozzles is used over and over again and is circulated by a small motor-driven centrifugal pump. When it becomes too dirty for further use, it is discharged to the sewer and a fresh supply taken. Between the spray chamber and the fan intakes is the eliminator, consisting of a number of rows of inclined baffle plates, which are in reality vertical strips of sheet copper 6 inches wide, provided with hook edges on the side toward the fan to catch the particles of water.

All of the supply systems except one are provided with tempering coils, which have a total heating surface of 87,042

linear feet of 1-inch pipe, and for the most part are 1-inch pipe screwed into manifolds on the steam and return ends on 2½-inch centers. From the fans to the flues making connection with the various sections of the building, connections are made by means of brick ducts underneath the floor, or by means of galvanized-iron ceiling ducts. In general these connections are proportioned for a velocity of flow of about 1200 feet per minute, and the vertical flues for a velocity of 500 to 600 feet per minute. In practically all cases the ducts have been run below the piping system, so that it would not be necessary to pass the pipes through them. In the basement all fresh-air duct work is covered with magnesia block 1 inch thick; this is wired on and is covered with 10-ounce canvas. All flues at points above the basement are covered in the same way, and the tempering coils and fan casings and the connections between them, as well as the centrifugal exhaust-fan casings are covered with the same material 1½ inches thick. In practically all cases the registers in the various rooms are located in the upper portions, and the supply of fresh air directed downward.

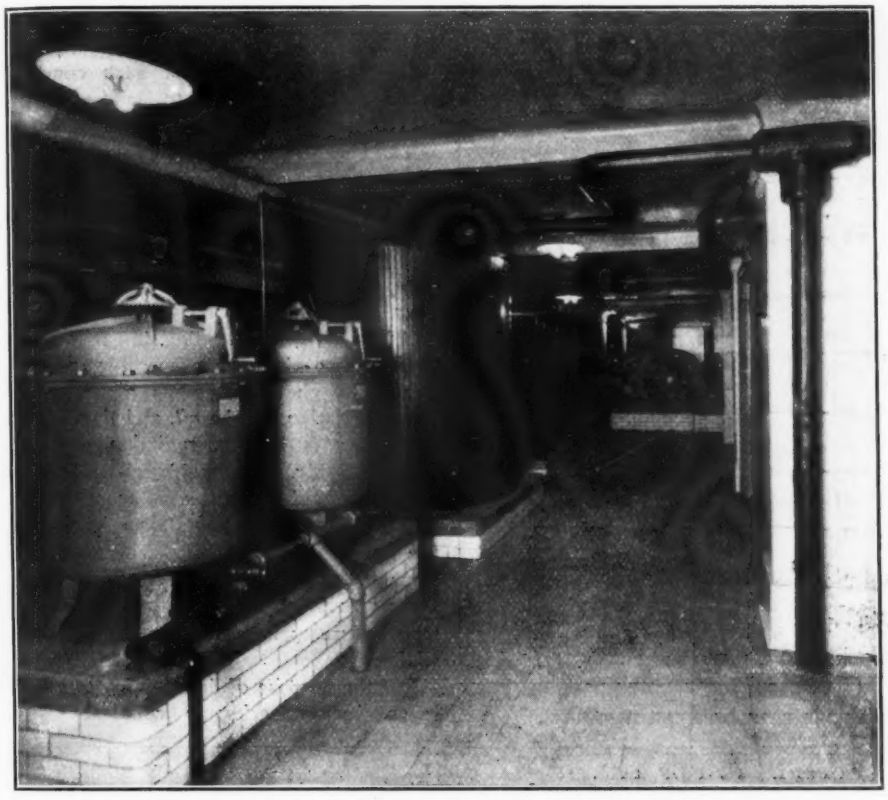


FIG. 15. WATER FILTERS, COOLING TANK AND VACUUM CLEANING APPARATUS

For the exhaust system a total capacity of 650,000 cubic feet per minute, distributed among 30 fans, has been provided, and these are more generally distributed throughout the building than are the supply fans. Some of the equipments are located in the basement, but a larger number have been installed in the attic at points convenient to the exhaust flues. Disk fans of the Blackman type were used wherever conditions would warrant, and in all there are 21 equipments of this type; 19 of these are located in the attic and are arranged to draw through vertical flues, the air escaping through roof-discharge hoods. The other nine equipments were by necessity centrifugal exhaust fans, due to the long gathering duct lines and the long vent risers discharging the air.

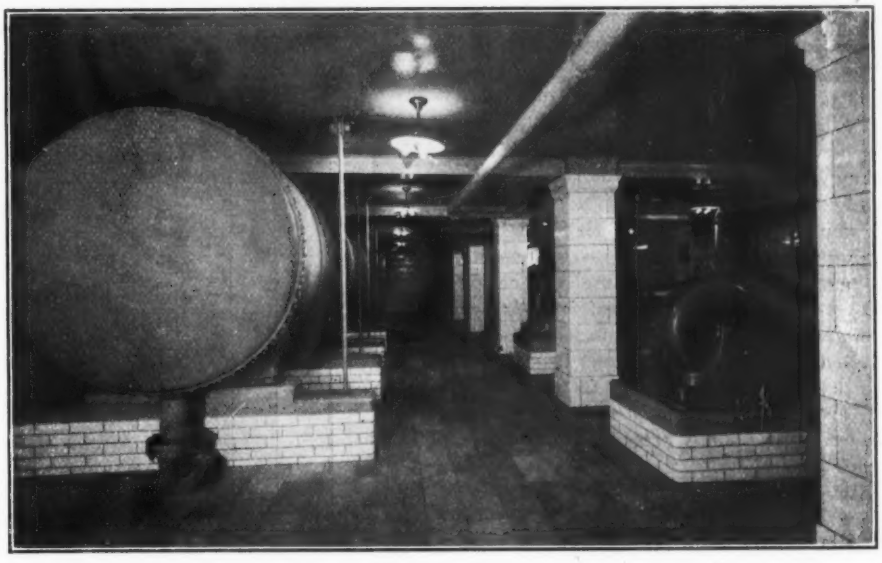


FIG. 16. ELEVATOR PRESSURE TANK AND VACUUM CLEANING MACHINES

Refrigeration

Some refrigeration for cooling the drinking water and for service in a kitchen to be installed in the institute was made necessary, and a system of 10 tons capacity has been installed. A vertical Frick compressor, driven by a horizontal Corliss engine, compresses the ammonia which cools the drinking water. For this purpose the ammonia is expanded directly in coils in a 1000-gallon tank and cools the water to 42 degrees Fahrenheit. The water is circulated to the various outlets in the building by a Gardner piston pump, 6x4x6 inches. In the kitchen brine circulation is to be employed, and the brine tank and pump are ready for this service.

Hydraulic Elevators

In this department there are three Otis plunger elevators for carrying passengers. These have a lifting capacity of 5000 pounds each and were designed to run at a speed of 250 feet per minute. There is also a freight elevator, with a platform 13 feet 6 inches by 17 feet 9 inches. At the usual working pressure of 150 pounds per square inch, this elevator will lift 10,000 pounds, but its capacity can be doubled by the use of a jack pump, which is a Wilson-Snyder, 10x6x15 inches, of the duplex type. The regular pressure on the system is turned into this pump and is increased to 300 pounds, giving the freight elevator a lifting power of 20,000 pounds. The usual pumping equipment is a duplicate set of Wilson-Snyder outside-packed plunger pumps, which are duplex tandem compound, with dimensions 14x22x18½x24 inches. Another elevator pump of the same make, 10x7x18 inches, has been provided for night service. The pumps all discharge into a large pressure tank 6 feet in diameter by 36 feet long, and the returns from the elevators are collected in a large open tank, having a capacity of approximately 8000 gallons.

Vacuum Cleaning

To be thoroughly uptodate, the building was equipped with a vacuum-cleaning system installed by the Vacuum Cleaner Company, of New York City. This is used principally to clean the floors and to draw dust from rugs and all upholstered work. The equipment consists of a double filter, in which the coarse dirt is removed first, and the air with the finer particles of dust is discharged under water into the second filter. A duplicate set of suction engines, 12x15 inches, is provided.

Compressed-air Supply

There is considerable use for compressed air in the plant. It is used to blow dust out of the generators, from the plumage of stuffed birds and similar uses, and is also required in the elevator pressure tank. The installation supplying the air is a National Brake and Electric Company compressor, which is single-stage and compresses the air to 90 pounds. It is driven by a 35-horsepower National Electric motor, running at 150 revolutions per minute, and at this speed the compressor has a capacity of 200 feet of free air per minute. The motor is automatically controlled from a Cutler-Hammer board. The air is stored in a reservoir 3 feet in diameter by 10 feet long, and is uniformly maintained at 90 pounds pressure by an automatic control.

Baker, Smith & Co., of New York City, were the engineers and contractors in charge of the entire installation, and to them much credit is due for the excellent arrangement and design of the plant.

In discussing the function of oxygen in the corrosion of iron Prof. W. H. Walker said that internal protection of boilers could be provided by merely keeping out the oxygen, ordinarily carried by feed water, by a preheater and a dry-vacuum pump.

Relative Rate of Heat Transfer to Water At and Below the Boiling Point

By W. M. Sawdon

The writer was much interested in the article entitled "Tests on Live Steam Feed Water Heating," by Sydney Bilbrough, in a recent number of Power and The Engineer. One of his statements is "that the rate of heat transmission through a boiler plate is exactly the same from a fire or flames to cold water as it is to boiling water."

On carefully reading this article it appeared that such broad generalizations on so simple and crude an experiment were not justifiable. This is especially true when we consider that his deductions are exactly contrary to the most modern thought along the lines of heat transfer. Mr. Bilbrough does not explain how he prevented radiation nor how he corrected for it and from his conclusions it would appear that he either forgot or neglected that very important factor. It does not seem fair, therefore, that such conclusions should be allowed to stand without further consideration and proof.

The heat lost by radiation from a small piece of apparatus not properly insulated is likely to be large and is in no wise to be neglected. It depends upon the character of the apparatus as well as upon the time or rate of heating. Unfortunately, tests for radiation corrections are difficult and likely to be misleading, but it is self-evident that when the temperature of the water and the surrounding air are the same, radiation will be *nil*, and that when the water is boiling, radiation will be greatest. Mr. Bilbrough's own experiments might then be used as proof of the falsity of his conclusions, since he found the apparent transfer of heat to be the same at the high temperature, when there was much radiation, as at the low temperature when the radiation was slight.

For the purpose of determining to what extent such experiments could be depended upon and wherein Mr. Bilbrough had failed in his observations, some simple tests of a similar character were made in the laboratory of Sibley College.

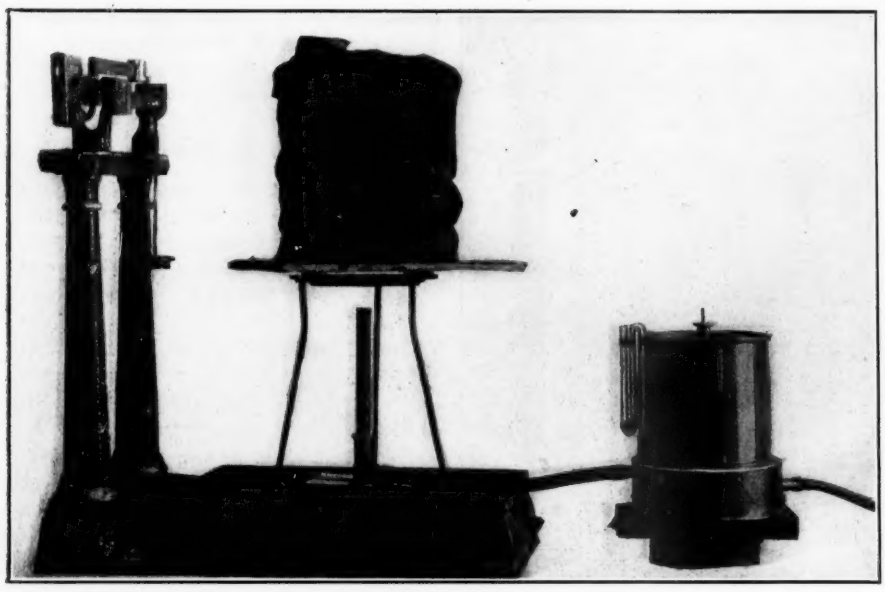


FIG. I. APPARATUS FOR DETERMINING RELATIVE RATE OF HEAT TRANSFER

TABLE 1. TEST OF RATE OF HEAT TRANSMISSION AT AND BELOW BOILING TEMPERATURE.

WITH HAIR FELT JACKET.

Weight of water, 2 lb. Date, June 22, 1908.

Time.	Diff.	Temperature. Water.	Air.	Diff.	Mean Diff.	Weight, Gross.	B.t.u. In Liquid Above Initial.	Taken up by Steam.	Total Above Initial.	Loss by Radiation. Per Min. From Curve.	In Time Increment.	Total.	Total B.t.u. Transmitted.
2:57		89.5	87	2.5		10.32							
3:00	3	108.0		21.0	12.0	10.32	37.0		37	0.04	0.12	0.1	37.0
03	6	150.0		63.0	42.0	10.32	121.0		121.0	0.42	1.5	1.6	122.5
06	9	182.0	88	94.0	78.5	10.31	195.0		195.0	1.30	3.9	5.5	200.5
09	12	207.0		119.0	106.5	10.30	235.0	9.5	244.5	2.5	7.5	13.0	257.5
*095	12.5	211.0		123.0	121.0	10.29	243.0	19.5	262.5	3.26	1.6	14.6	277.0
12	15	211.2	88	123.0	123.0	10.24	243.5	77.5	321.0	3.37	8.4	23.0	344.0
15	18	211.2		123.0	123.0	10.16	243.5	154.5	398.0	3.37	11.0	34.0	432.0
18	21			123.0	123.0	10.07	243.0	241.5	484.5	3.37	11.0	45.0	529.5
21	24		88.5	122.5	123.0	9.98	243.0	328.5	571.5	3.37	11.0	56.0	627.5
24	27			122.5	122.5	9.90	243.0	405.5	648.5	3.33	11.0	67.0	715.5
27	30			122.5	122.5	9.80	243.0	502.5	745.5	3.33	11.0	78.0	823.5
30	33		89	122.0	122.5	9.71	243.0	589.5	832.5	3.33	11.0	89.0	921.5
33	36			122.0	122.0	9.63	243.0	666.5	909.5	3.32	10.0	99.0	1008.5
36	39			122.0	122.0	9.55	242.5	744.0	986.5	3.32	10.0	109.0	1095.5
39	42		89.2	122.0	122.0	9.47	242.5	821.0	1063.5	3.32	10.0	119.0	1182.5
42	45			122.0	122.0	9.39	242.5	898.5	1141.0	3.32	10.0	129.0	1270.0
45	48			122.0	122.0	9.30	242.5	985.5	1228.0	3.32	10.0	139.0	1367.0
48	51		89.2	122.0	122.0	9.22	242.5	1062.5	1305.0	3.32	10.0	149.0	1454.0
51	54			122.0	122.0	9.14	242.5	1140.0	1382.5	3.32	10.0	159.0	1541.5
54	57			122.0	122.0	9.05	242.0	1227.0	1469.0	3.32	10.0	169.0	1638.0
57	60		89.5	121.5	122.0	8.97	242.0	1304.0	1546.0	3.32	10.0	179.0	1725.0
4:00	63			121.5	121.5	8.88	242.0	1391.0	1633.0	3.28	9.8	189.0	1822.0
03	66			121.5	121.5	8.80	242.0	1468.5	1710.5	3.28	9.8	199.0	1909.5
4:06	69		90	121	121.5	8.71	242.0	1555.5	1797.5	3.28	9.8	208.0	2005.5

*Boiling.

Apparatus

The apparatus was somewhat similar to that employed by Mr. Bilbrough and will

be clearly understood by reference to the photograph, Fig. 1. The tank was made from an old Carpenter calorimeter from which the bottom had been removed. A stirring device, consisting of a ring of sheet metal turned down at the edge for stiffness and having a small rod soldered on for a handle, was inserted and then a new bottom soldered on. This left three holes in the top, one through which the stirring rod passed, one for the thermometer and the third for the steam to pass out.

A rectangular piece of asbestos board, 10½x12 inches and ¼ inch thick, was cut out at the center so as to fit closely over the outside of the calorimeter. This was slipped on so that the bottom of the board was flush with the bottom of the calorimeter. It served the double purpose of defining the heating surface (0.165 square foot) and of protecting any insulating material which might be placed around the calorimeter.

The heat supply was a gas flame from a special burner belonging to the Junker calorimeter and the pressure of the gas was kept constant by a pressure regulator. This pressure was equal to 10 millimeters of water and the gas was from the city mains.

The thermometer had a range of 250 degrees Fahrenheit, was graduated in degree divisions and could readily be estimated to ¼ degree. Readings closer than ½ degree were not thought to be justifiable in this experiment and were not attempted.

The calorimeter was placed on two small square rods upon an iron stand and this, together with the burner, rested upon a small platform scale. The scale was graduated to fiftieths of a pound, permitting reading to hundredths of a pound.

TABLE 2. RADIATION TEST, WITH HAIR FELT JACKET.

Weight of water, 2 lb. Date, June 23, 1908.

Time. Actual.	Time. Diff.	Temperature. Water.	Temperature. Air.	Temperature. Diff.	Temperature. Mean Diff.	Weight, Gross.	B.t.u. In Liquid Above Initial.	Loss by Radiation. Total.	Loss by Radiation. Diff.	Loss by Radiation. Per Min.
9:24		78.5	80			10.32				
27	3	104.0	80			10.32	51			
30	6	145.0	80			10.31	133			
33	9	174.0	81			10.31	191			
36	12	203.0				10.30	249			
37	13	211.0				10.30	265			
*9:38	14	211.5	81	130.5		10.27	266			
40	16	210.0		129.0	130.0	10.26	263	3	3	1.5
43	19	206.5		125.5	127.5	10.25	256	10	7	2.33
46	22	202.0	81	121.0	123.5	10.24	247	19	9	3.0
49	25	197.5		116.5	118.9	10.23	238	28	9	3.0
52	28	193.0		112.0	114.5	10.22	229	37	9	3.0
55	31	189.0	81	108.0	110.0	10.21	221	45	8	2.67
10:00	36	183.0		102.0	105.0	10.20	209	57	12	2.4
05	41	177.5		96.5	99.5	10.20	198	68	11	2.2
10	46	173.0		92.0	99.5	10.19	189	77	9	1.8
15	51	169.0		88.0	90.0	10.19	181	85	8	1.6
30	66	158.0	82	76.0	82.0	10.17	159	107	22	1.47
45	81	149.0	82	67.0	71.5	10.17	141	125	18	1.2
11:00	96	142.5		60.5	64.0	10.16	128	138	13	0.87
15	111	136.5	84	52.5	56.5	10.16	116	150	12	0.8
30	126	132.0		48.0	50.5		107	159	9	0.6
12:00	156	123.5	84	39.5	44.0	10.13	90	176	17	0.57
2:30	186	103.0	87	16.0	28.0	10.13	49	217	41	1.37
5:00	336	96.5	89	7.5	12.0	10.12	36	230	13	0.09

*Boiling, gas turned off.

TABLE 3. TEST OF RATE OF HEAT TRANSMISSION AT AND BELOW BOILING TEMPERATURE.

WITHOUT JACKET ON CALORIMETER.

Weight of water, 2 lb. Date, July 11, 1908.

Time.	Diff.	Temperature. Water.	Temperature. Air.	Temperature. Diff.	Temperature. Mean Diff.	Weight, Gross.	B.t.u. In Liquid Above Initial.	B.t.u. Taken up by Steam.	B.t.u. Total Above Initial.	Loss by Radiation. Per Min. From Curve.	Loss by Radiation. In Time Increment.	Loss by Radiation. Total.	Total B.t.u. Transmitted.
8:24		75.5	75	0.5		9.55							
27	3	107.0		32.0	16.0		63.0		63	0.22	0.5	0.5	63.5
30	6	137.0	75	62.0	47.0		123.0		123	1.20	3.5	4.0	127.0
33	9	168.0		93.0	77.5	9.54	185.0	9.5	194.5	2.42	7.5	11.5	206.0
36	12	195.5		120.5	106.8		240.0	9.5	249.5	3.97	12.0	23.5	273.0
*8:38	14	211.0	76	135.0	127.8	9.53	271.0	19.5	290.5	5.22	10.5	34.0	324.5
41	17	211.0		135.0	135.0	9.48	271.0	67.5	338.5	5.67	17.0	51.0	389.5
44	20	211.0		135.0	135.0	9.42	271.0	125.5	396.5	5.67	17.0	68.0	464.5
47	23	211.0		135.0	135.0	9.35	271.0	193.0	464.0	5.67	17.0	85.0	549.0
50	26	211.0		135.0	135.0	9.28	270.5	261.0	531.5	5.67	17.0	102.0	633.5
55	31		77	134.0	135.0	9.19	270.5	348.0	618.5	5.67	17.0	119.0	737.5
9:00	36			134.0	134.0	9.07	270.5	463.5	734.0	5.60	28.0	147.0	881.0
05	41			134.0	134.0	8.97	270.5	560.5	831.0	5.60	28.0	175.0	1006.0
10	46			134.0	134.0	8.85	270.5	676.0	946.5	5.60	28.0	203.0	1149.5
15	51			134.0	134.0	8.74	270.0	782.5	1052.5	5.60	28.0	231.0	1283.5
20	56			134.0	134.0	8.63	270.0	888.5	1158.5	5.60	28.0	259.0	1417.5
25	61			134.0	134.0	8.53	270.0	985.5	1255.5	5.60	28.0	287.0	1542.5
30	66			134.0	134.0	8.41	270.0	1001.0	1371.0	5.60	28.0	315.0	1686.0
35	71		78.5	132.5	134.0	8.30	270.0	1207.5	1477.5	5.60	28.0	343.0	1820.5
40	76			132.5	132.5	8.19	269.5	1314	1583.5	5.5	27.5	370.5	1954.0
45	81			132.5	132.5	8.08	269.5	1420	1689.5	5.5	27.5	398.0	2087.5

*Boiling.

Method

Two pounds of water was carefully weighed on an accurate balance and poured into the calorimeter. After allowing this to stand for a sufficient length of time for the temperature conditions to become steady, it was thoroughly stirred and the temperature taken. The gas was then quickly lighted and the time, temperature and weight noted. Readings were taken at short intervals until most of the water had boiled away.

The log and results of these experiments, both with a hair-felt jacket on the calorimeter and with no jacket, are shown in Tables 1 and 3, respectively.

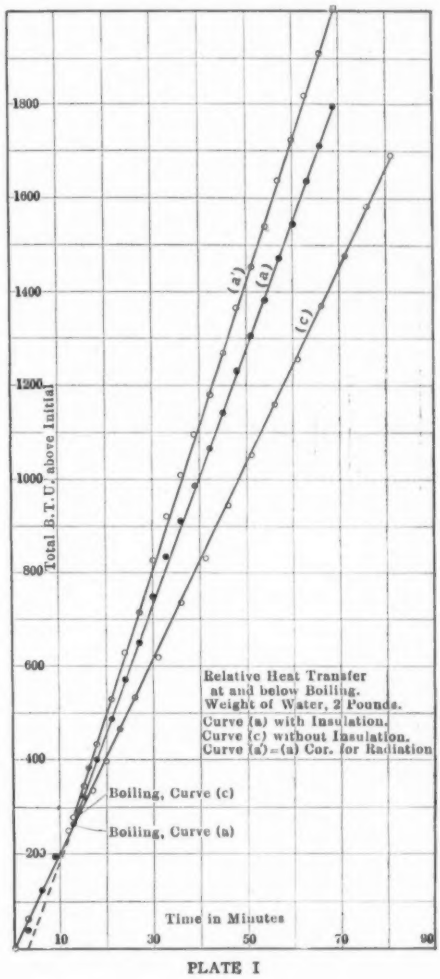


PLATE I

Tests were also made for radiation by proceeding as before, but in this case the gas was turned off at the instant the water began to boil and the loss of heat from that time noted. The log and results for these two tests are shown in Tables 2 and 4.

Results

The results of tests (Tables 1 and 3) are shown graphically by curves *a* and *c* in Plate 1. The total heat above initial is the heat of the liquid above the initial plus the heat passing off with the steam.

This is used as ordinates and the time in minutes as abscissas in plotting the curves. Curve *a* is made up of two straight lines which meet in an angle at the boiling point and clearly shows that the rate of heat transfer is greater above than below this point. The dotted line is an extension of the upper end of *a*. Curve *c* is plotted in the same way and is one continuous straight line. This shows that with no insulation and no correction for radiation the rate of heat transmission remains the same. This result corresponds to that of Mr. Bilbrough and shows plainly wherein he failed.

In order to make the radiation correction, the mean difference in temperature of water and air for each small interval of time and the corresponding loss of heat per minute were calculated. These were then plotted as shown in Plate 2. As might be expected, the upper ends of

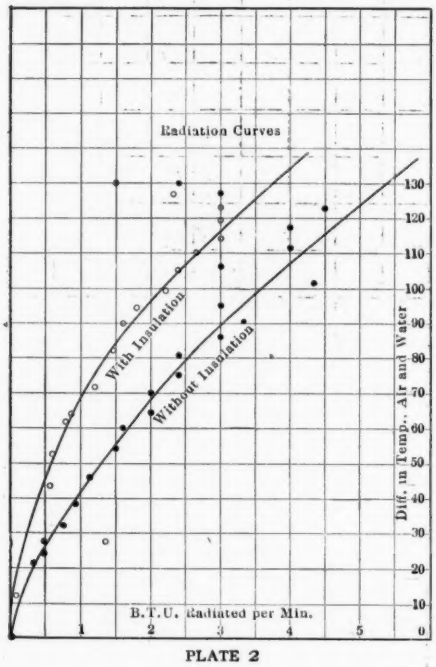


PLATE 2

these curves afford little definite information of the radiation at the higher temperatures. The reason for this is that parts of the apparatus such as the iron stand, the asbestos board and even the lower end of the hair-felt jacket acquire a temperature much higher than that of the water and these parts yield up heat to the water for a considerable time after the gas is turned off, and the radiation through this period appears to be only a small part of what it really is. The water equivalent of the apparatus might be found, but this would be useless since the temperature of the several parts could not be easily measured.

The best that can be done, then, in the way of correcting for radiation is to produce the curve found for the lower part of the range where it is consistent. This is the manner in which these curves were drawn and while they are not absolute they are conservative, especially in the case of the noninsulated test. From these curves the radiation was taken and applied to tests (Tables 1 and 3) and a curve *a'* so corrected was drawn on Plate 1. The corresponding curve for *c* falls so close to curve *a* that it was omitted.

If the efficiency of the heating surface remained the same with the jacket on the calorimeter as without, then these corrected curves should coincide, since the B.t.u. supplied times efficiency of transfer equals B.t.u. in liquid above initial plus B.t.u. carried away with the steam plus B.t.u. lost by radiation.

It is quite probable that the efficiency of transfer is slightly greater in the case of the insulated test since the hair felt near the bottom would become heated and transmit some heat to the water.

Summary

(1) Test with calorimeter jacketed, radiation disregarded. B.t.u. absorbed below boiling point (12.5 minutes) = 262.5 B.t.u. per hour =

$$\frac{262.5 \times 60}{12.5} = 1260$$

B.t.u. absorbed above boiling point (56.5 minutes) = 1535 B.t.u. per hour =

$$\frac{1535 \times 60}{56.5} = 1630.$$

Gain by hot water over cold,

$$\frac{1630 - 1260}{1260} = 29$$

per cent.

(2) Test with calorimeter bare, radiation disregarded. B.t.u. absorbed below boiling point (14 minutes) = 290.5 B.t.u. per hour =

$$\frac{290.5 \times 60}{14} = 1245$$

B.t.u. absorbed above boiling point (67 minutes) = 1399 B.t.u. per hour =

$$\frac{1399 \times 60}{67} = 1253.$$

Gain by hot water over cold,

$$\frac{1253 - 1245}{1245} = 0.64$$

per cent.

(3) Test with calorimeter jacketed and corrected for radiation. B.t.u. absorbed below boiling point (12.5 minutes) = 277 B.t.u. per hour =

$$\frac{277 \times 60}{12.5} = 1329$$

B.t.u. absorbed above boiling point (56.5 minutes) = 1728.5 B.t.u. per hour =

$$\frac{1728.5 \times 60}{56.5} = 1835.$$

Gain by hot water over cold,

$$\frac{1835 - 1329}{1329} = 38$$

per cent.

TABLE 4. RADIATION TEST, WITHOUT JACKET ON CALORIMETER.

Weight of water, 2 lb. Date, July 11, 1908.

Time.		Temperature.			Mean Diff.	Weight, Gross.	B.t.u. in Liquid Above Initial.	Loss by Radiation.		
Actual.	Diff.	Water.	Air.	Diff.				Total.	Diff.	Per Min.
10:14		76.5	78.5			9.54				
17	3	107.5				9.54	62.0			
20	6	138.5				9.54	124.0			
23	9	170.0	79.0			9.53	187.0			
26	12	198.0				9.53	242.0			
*27½	13.5	211.0		132.0		9.52	269.0			
30	16	208.0	80.0	128.0	130.0	9.51	263.0	6	6	2.4
32	18	205.0		125.0	126.5	9.50	257.0	12	6	3.0
34	20	200.5		120.5	123.0	9.50	248.0	21	9	4.5
37	23	194.5		114.5	117.5	9.50	236.0	33	12	4.0
40	26	188.5	80.0	108.5	111.5	9.49	224.0	45	12	4.0
43	29	184.0		104.0	106.5	9.49	215.0	54	9	3.0
46	32	177.5		97.5	100.5	9.49	202.0	67	13	4.33
49	35	173.0		93.0	95.5	9.48	193.0	76	9	3.0
52	38	168.0		88.0	91.0	9.48	183.0	86	10	3.33
55	41	163.5		83.5	86.0	9.48	174.0	95	9	3.0
11:00	46	157.5		77.5	80.5		162.0	107	12	2.4
05	51	152.0		72.0	75.0		151.0	118	11	2.2
10	56	147.0	80.0	67.0	70.5		141.0	128	10	2.2
15	61	142.0		62.0	65.0		131.0	138	10	2.2
20	66	138.0		58.0	60.0		123.0	146	8	1.6
30	76	130.5		50.5	54.5		108.0	161	15	1.5
45	91	122.0		42.0	46.5		91.0	178	17	1.13
12:00	106	115.0		35.0	38.5		77.0	192	14	0.93
15	121	109.5		29.5	32.5		66.0	203	11	0.73
30	136	105.5		25.5	27.5		58.0	211	8	0.53
45	151	102.0		22.0	24.0		51.0	218	7	0.47
1:00	166	99.5		19.5	21.0		46.0	223	5	0.33

*Boiling, gas turned off.

Weight of water actually evaporated = 1.61 pounds.

Weight of water evaporated per hour per square foot of heating surface =

$$\frac{1.61 \times 60}{69 \times 0.165} = 8.48$$

pounds.

Conclusions

(1) That with no protection from radiation the loss of heat may be sufficient entirely to eclipse the gain by boiling water.

(2) That there is a gain in the rate of heat transfer by boiling water over cold water of at least 38 per cent. in an apparatus of this kind. Actual boiler tests in the Sibley laboratories have confirmed this latter conclusion. As to whether this gain is due to rapid circulation of the water remains for future experiments to prove.

Coal; Its Composition and Combustion*

General Discussion of the Elements which Combine to Promote Combustion; How to Ascertain the Degree of Combustion Attained

BY WILLIAM H. BOOTH

It is usual to speak of heat under various names. It is thermometric, specific, or latent. By the first is meant that property of heat which sets up molecular vibrations in a substance, which are capable of transmission to surrounding bodies by radiation or by contact.

By specific heat we mean the amount of heat energy that is necessary to set up a certain degree of thermometric heat in a unit or mass of some body. The same addition of heat to a pound of lead that has made a pound of water comfortably warm would enable the lead to burn a hole through a man's hand.

By latent heat is understood heat that has become converted into energy of condition without thermometric manifestation, as when heat added to ice at 32 degrees Fahrenheit enables that ice to exist as a free liquid and still only to affect the thermometer to 32 degrees Fahrenheit. Here, heat represents mobility of the molecules.

In a wide general sense every chemical reaction may be cited as a combustion. Certainly the converse is true—combustion is a chemical reaction. All substances are, in a broad sense, fuels. Many are difficult to ignite. Many have already entered into combustion or are results of chemical processes so energetic that it is difficult to establish any other reaction. Lime, for example, is the product of a combination of the metal calcium with the gas oxygen, and the energy of union is so great that the metal calcium, though one of the most common of nature's so-called elements, is hardly known except as an oxide or a carbonate.

Aluminum is a metal that unites so firmly with oxygen that it will usurp the place of iron in a mass of burned iron, and convert a mass of mill scale into pure iron by itself becoming an oxide. Hence the thermit process. The fuels that are commonly regarded as fuels are wood and coal and mineral oils. These are found free in nature, and are easily burned and give out considerable heat. Ages of experience have taught us that air is necessary to combustion. The fire of wood burns the better when the wind blows upon it. The wind we can feel, if we cannot see it. The effect is to blow away the CO_2 and leave the fuel freely exposed to fresh supplies of oxygen.

Carbon gas is ideal only. Carbon exists, as gas, in the electric arc at 3600 degrees Centigrade. When carbon is burned to monoxide, CO, there are set free 4415 B.t.u. per pound. When this monoxide is burned to dioxide a further heat of 10,232 B.t.u. is set free. Why the difference? Physicists say that the first oxidation also generates at least 10,232 B.t.u. or 5817 units more than is thermometrically discoverable. They say that the 5817 units have become latent because the carbon which was solid is now gaseous in the CO. Therefore, the total heat of combustion of carbon gas, if carbon could be taken in its gaseous form, is $10{,}232 \times 2 = 20{,}464$ B.t.u. per pound.

Now, in CO_2 there are 12 degrees of C and 32 degrees of O, or

$$C : O :: 3 : 8.$$

Then

$$20{,}464 \times \tfrac{3}{8} = 7674$$

B.t.u. produced by the combustion of 1 pound of oxygen.

Now, for combustion with hydrogen: One pound of this gas gives 62,100 B.t.u. The ratio of the two elements H_2O is 1 : 8.

Now,

$$62{,}100 \times \tfrac{1}{8} = 7763$$

B.t.u. This is almost exactly the heat developed when oxygen is destroyed by gaseous carbon.

In each case three volumes of gas become two volumes, so there is no difference due to a different degree of condensation. Let there be next taken the heat of combustion of a series of hydrocarbons: C_2H_2, C_2H_4, CH_4, C_2H_6 and C_6H_6. These are shown in the second column in B.t.u. per pound of the hydrocarbon. In the third column is the ratio of the oxygen consumed, and in the fourth the heat units per pound of oxygen used. This table gives room for thought. It shows, in the first place, a gradually decreasing result in heat set free per pound of oxygen destroyed. Between C_2H_2 and C_6H_6 two hydrocarbons, with exactly the same proportions of carbon and hydrogen, using up exactly the same weight of oxygen per pound of each, there is a difference of heat set free of 17 per cent. (nearly). Burned as vapor and burned as liquid, benzine or C_6H_6 gives a different amount of heat again. The figures become confusing when thus treated, and it is necessary to deal with them by the molecule, as they are treated by the chemist.

	B.t.u.		B.t.u.
C_2H_2	21,850	$\times \frac{26}{80}$	= 7,003
C_2H_4	21,927	$\times \frac{28}{96}$	= 6,396
CH_4	24,017	$\times \frac{16}{64}$	= 6,003
C_2H_6	22,338	$\times \frac{30}{112}$	= 5,983
C_6H_6	18,094	$\times \frac{78}{240}$	= 5,880
for benzine vapor.			
C_6H_6	17,930	$\times \frac{78}{240}$	= 5,827
for benzine liquid.			

How coal is formed cannot be said with absolute certainty, but the probability is that the coal plants accumulated like the accumulation of the peat bogs and became buried in sand and gradually sank to a considerable depth in the earth. There under the influence of heat and pressure, the vegetable matter changed its nature. Its watery constituents were driven off and the remaining portions carbonized, and then were also set up those reactions that produced what we term the bituminous quality. There is no bitumen in coal, but what we mean by bituminous is known to all. Some coal was so much heated that its hydrocarbonaceous matter was driven off to be absorbed in other rocks, such as certain clay shales, or it escaped to the surface and was lost. Thus possibly the Welsh coal was formed with its short flaming qualities that earn for it the term "smokeless," because, though not smokeless in all circumstances, it can be burned without smoke if any simple precautions are taken. Exposed to still greater heat or pressure or both almost all the hydrogenous matter is driven off and the coal is converted into anthracite, a flinty hard variety of carbon.

If samples of coal be examined their composition cannot be regarded as so different as is their behavior. There is a substance found in parts of the West Indies which resembles anthracite in appearance, but it is plastic brittle. It is said not to contain more than 1 per cent. of hydrogen to 99 of carbon. Yet this 1 per cent. entirely changes the nature of the carbon, producing a smoky fuel and the capacity of becoming soft with but a moderate heat. Ordinary bituminous coal contains very much more hydrogen but does not soften at the same low temperature, and when it is exposed to heat it softens in spots and gives off tar vapors. Nothing is known really of the chemical composition of coal. It can be found out easily and with close accuracy just how much hydrogen, how much carbon, oxygen or sulphur a piece of coal does contain, but how the atoms of these

*Abstract of paper read before the Association of Engineers-in-Charge (England), December 9, 1908.

elements are joined together seems quite beyond finding out. Thus, if a piece of coal be exposed to distillation in a retort and the different things collected that are produced, there will be found tar, creosote, carbolic acid, cresylic acid, hydrogen, various light and heavy hydrocarbon gases, and so much water and ammonia. But it cannot be said these substances are present in the coal. They have simply been built up or broken down from the material of which coal is really formed, and for anything known to the contrary, a piece of bituminous coal is homogeneous throughout in chemical composition and only splits up into many and various bodies when heated. But since it cannot be known what this substance is there is no reason further to inquire into it. And it may be inferred that if the coal begins to split up as soon as heated so it will continue to split up as more heat is applied, the material splitting up more and more into lighter and heavier portions so that nothing but pitch remains in the still, and after a little further heating, even this is resolved into coke and vapor.

When coal is burned in a fire exposed to air, there is a perhaps more complicated set of reactions put into operation. These are operations both of distillation and combustion. An experiment first shown by Horace Allen was the sprinkling upon a red-hot plate of porcelain of some finely divided bituminous coal. At once vapor commences to be given off and a dark spot surrounds each bit of coal. The coal does not glow so long as the vapor is coming away from it. When the vapor ceases to escape the coal begins to get hot and the dark spots on the plate disappear. The coal now begins to glow, to sparkle—in fact, to oxidize and disappear.

Now, from this experiment much may be learned. First, that the primary effect of heating coal is to drive off its volatile portions. Actually, of course, heat renders the coal partly volatile and drives this part away. The vaporizing of this demands heat and the vapor renders so much heat latent that it dulls the surface of the plate. When this chilling effect is finished by the escape of all vapor, the remaining bit of coke gradually becomes hotter. But it does not oxidize brightly until it has attained a high temperature. These actions teach that coal upon a grate will be very seriously cooled if fresh coal is thrown upon it, and that the volatile matter must be thrown off any piece of coal before its carbon skeleton will begin to burn. In a thick bed of coked coal on a grate the chilling effect of fresh coal may not extend right down to the grate surface and the fuel next the grate will burn with the incoming air at the same time as the gas from the green coal burns on the surface. If the fuel bed is thin, the carbon dioxide first produced on the grate comes to the surface as dioxide, and hinders the combustion of the volatile matter. If the fuel be thick the dioxide may be converted into monoxide in its upward passage through the fuel, and this will again hinder the combustion of the volatiles. The final gaseous mixture above the fuel will be very complex, and usually it will be by no means very hot. Experience tells, as explained by Mr. Swinburne, that this mixed mass ought to be kept hot in a nonabsorbent furnace until combustion is complete.

What now deserves attention is a simple means of examination of a fire with the object of ascertaining to what degree combustion has attained. This is blue glass of a deep tint. Blue glass will not permit the passage of light of a wave length greater than blue. It is because it will not permit this that it is blue. High-temperature radiation has the shortest wave length. Violet light has double the number of waves per inch that represent red light, and red light has millions of times the waves per inch of sound notes. Sound would become visible to a man moving fast enough toward its vibratory origin. Low-temperature flame is red, orange, yellow; blue is hot; violet is so potent that it brings about various chemical reactions, as in photography. A red-hot brick seen through blue glass becomes drab, and gives no illumination. A brilliantly incandescent brick-lined furnace seen through blue glass appears of a light French gray, and is of illuminating quality.

Now, if a dull flaming fire be observed, such as is obtained if badly mixed gases rise directly upward from the fire to pass among cold tubes, there will be seen through blue glass no illumination above the fire beyond about 6 inches. The flames are resolved into dark streams of gas; no light comes from them. But if the interior of a furnace be observed when properly lined with brick, and with suitable direction of flow and air mixture, the whole will be illuminated. Streaks and splashes of dark gas will be seen coming forward over the fire, and these melt away as they travel, and burn and help to keep up the temperature. The dark streaks are simply gas not hot enough to give violet light. They are red or yellow flames of burning gas ready to produce smoke if sent upon cold surfaces. Kept off cold boiler plates, they complete their high temperature combinations, and may then be used for heating anything.

It is not that blue glass marks the state of combustion beyond which one must pass, but it seems certain that if a properly mixed gas attains this temperature before exposure to cold surfaces, it will be properly burned. It would be interesting to experiment with red, yellow, and green glass, so as to find how these help in analyzing the state of a fire. It is certain that if blue glass cuts the flame very short there is imperfect combustion.

Now I have not told you much about coal, for I know nothing myself of the way it is put together. All I can infer is that a very small amount of combined hydrogen will change the physical nature of much carbon. Analysis of coal seems to point to the presence of oxygen as the patent cause of so-called bituminosity. Knowledge of the phenomena of heat—such as latency—teaches that the fuel bed must be chilled when fresh coal is giving off vapor.

On the supposed atomic arrangement of hydrocarbon, speculation may be indulged in on the facts that hydrocarbon is first attacked by the oxygen, and that the carbon is set free by itself or in some different combination with hydrogen, and so readily condenses on the first cold surface. And so it is learned to mix atoms of oxygen in excess of what the hydrogen atoms will snatch up and to maintain everything hot until the carbon has had its chance to find its own atoms of oxygen. And as it may be inferred that a thick fuel bed implies shortness of oxygen above the fire—for the fire has perhaps been converted into a gas producer—so it may be learned not always to regulate combustion at the chimney damper, but to keep this open sufficiently to pull in all the air we need as a maximum above the fire, and to regulate the combustion by combined movements of the door grids and ashpit dampers.

Safety valves are locked up from tampering; why not also lock the chimney damper? It should be locked, for it is not fit to be used as a regulator of the combustion of bituminous coal, for this is a double process, the coal burning partially as solid fuel on the grate and partly as gas above the fire, and each operation requires separate and yet conjoint air regulation.

Ordinary coal has a calorific capacity of about 14,000 B.t.u. per pound. The volatile matters distilled from it have a capacity of 18,000 to 24,000 B.t.u. The extra 4000 to 10,000 heat units they now possess are borrowed from the heat of combustion of the solid fuel on the grate, and when the green gas is wasted unburned it is carrying with it the latent heat of distillation. Assuming 20,000 as its average heat value and assuming one-third of the coal to be volatile, the green gases carry off nearly half the heat value of the coal.

Though the molecular structure of coal may not be discoverable, there can be no doubt as to the results of the systems of combination ordinarily adopted. If fired on the coking system, the gas is driven off more or less steadily and continuously, and places less of a tax on the surface at any one moment in respect of maximum air supply above the fuel to burn the gas than is levied when fresh coal is spread heavily over a fire at more or less wide intervals of time.

The heat of combustion of carbon and hydrogen together is sometimes more and sometimes less than the heat necessary to

liquefy or gasify the carbon and to liquefy the hydrogen.

In solid fuel the carbon has not changed its state, but any hydrogen has been somehow rendered solid by its combination with carbon.

The gaseous hydrocarbons become liquid when their molecular weight gets up to about 70 to 80, and solids begin to appear when the molecular weight reaches 128 or 136.

The trouble with coal is that it is not simply a hydrocarbon of even unknown proportion, or a mixture of hydrocarbons. It contains oxygen built into its solid structure, and this oxygen is not necessarily there as water with some of the hydrogen as H_2O. But it is there, and it comes off in distillation, and forms that complex substance — tar. Tar contains phenol, which is C_7H_8O, the carbolic acid basis; and there are phenols with eight and nine carbon atoms, and even ten.

It would fill this whole paper only to name the known carbon organic compounds containing the three elements C, H and O variously hooked together. But with all the knowledge of the many substances given out from tar, it cannot be said they are present in coal in the form they take on. But the main facts of physics can be relied on. Heat is swallowed up when solids are liquefied or liquids gasified, and these are the things that happen to coal when burned. They retard its perfect combustion, and the engineer who can best fit practice to meet nature's laws on proper conditions will best utilize coal as regards economy and cleanliness. The knowledge of what happens thermochemically in the life history of the hydrocarbons furnishes ample explanation of the failure of ordinary methods of burning it without heat or temperature conservation. The behavior and properties of the gaseous hydrocarbons may be regarded as the gaps in the bounding walls of knowledge through which glimpses may be had sufficient to serve as the jumping-off points of the flying machines of speculative imagination; and after all it is imagination which differentiates the engineer from the mere mechanic. Armies are never likely to be conveyed by either balloon or flying machine, but both these frail craft may serve to point the way by which an army may best proceed. The mere speculative engineer will not perhaps carry out work so well as the constructional man who follows beaten paths, but his speculative habit of mind does enable him to point the way for others to follow.

Individual Motor Drive for Woodworking Machinery

In the town of Sheffield, Penn., the Central Pennsylvania Lumber Company has located a new lumber mill for sawing rough boards, as well as finished lumber. The total capacity of the plant is about 175,000 feet of lumber per day, largely hemlock. The mill is of concrete construction throughout, securing as great protection from fire as is possible in a woodworking mill.

As is the case with nearly all new mills, electric power has been determined upon for driving the entire equipment. Wherever possible the machines are direct-connected to their driving motors. Three-phase, 60-cycle, 400-volt, alternating current was decided as the most satisfactory under all the conditions of service, and a complete power equipment, including boilers, engines, generator, motors, and all the necessary measuring instruments and controlling devices, has been installed and arrangements made to burn the refuse from the mill under the boilers.

The logs are conveyed up the incline from the pond by a "log chain," or "log jacker," into the mill, the jacker being driven by a 15-horsepower back-geared motor running at 840 revolutions per minute. The chain is 190 feet in length and carries 33 steel dogs for gripping the logs. From the top of the incline the logs are rolled either to the right or the left, as the equipment is provided in duplicate; that is, on the right are band mills, gang edgers and trimmers arranged for receiving the lumber from the left, and there is a similar equipment on the left for receiving lumber from the right.

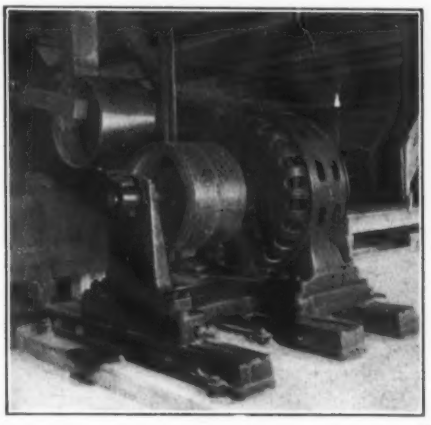


FIG. 1. MOTOR DRIVING AN 8-FOOT RE-SAW; 150 HORSEPOWER

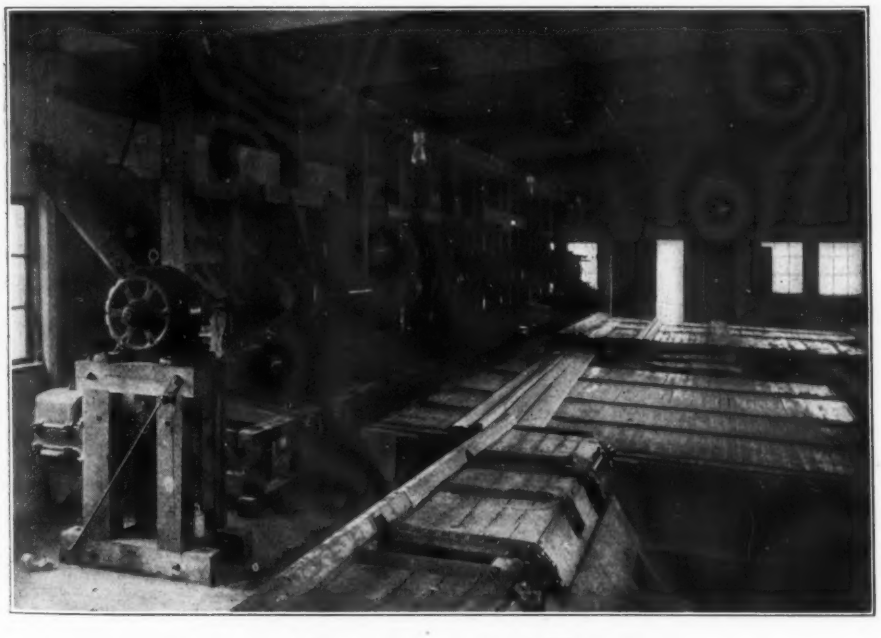


FIG. 2. TRIMMERS DRIVEN BY 30-HORSEPOWER MOTOR

The logs are first sawed into lumber by the 8-foot band mills, each of which is operated by a 150-horsepower motor running at 580 revolutions per minute. From both the band mills the sawed lumber is carried by line rolls and transfers to the one re-saw mill. Each set of seventeen 10x24-inch rolls is operated by a 7½-horsepower, 1120-revolutions-per-minute motor through a back gear on the motor.

The re-saw mill cuts the lumber into thinner planks and boards, except in the case of the larger sizes, where the first cut by the band mills is sufficient. The re-saw is driven by a 150-horsepower motor, 580 revolutions per minute. On this re-saw mill are two 8-foot band wheels with 14-inch face. The motor is connected by belt to the lower band-wheel shaft and gives to the saw a speed of about 9750 feet per minute.

From the re-saw the 1-inch and 2-inch material is carried by conveyers to the two gang edgers, which saw the broader boards into standard sizes, as 2x4 inches, 2x6 inches, 2x10 inches, 1x4 inches, or 1x6 inches, etc. Each gang edger has eight saws, 24 inches in diameter, and is operated by a 50-horsepower, 1700-revolutions per minute motor direct-connected to the shaft of the edger. After the lumber has passed through the edgers it is

carried by line rolls to the trimmers, which consist of a row of saws mounted on swinging arms driven by belts from a line shaft, from which they are hung. The saws are spaced for trimming off the lumber ends, leaving standard lengths. One trimmer has eight saws and the other ten. Each set is operated by a 30-horsepower motor running at 840 revolutions per minute. The motor also operates a No. 2 Clark Brothers pintle chain for conveying the lumber away. The ten-saw trimmer is known as the 6 to 22-foot automatic trimmer, and will handle material up to 6 inches in thickness. The eight-saw trimmer is rated as a 6 to 24-foot automatic trimmer for use on material up to 11 inches thick.

After being trimmed the lumber is conveyed on a chain through the assorting shed where it is loaded onto cars by manual labor. The chain travels at the rate of 32 feet per minute, being driven by a 15-horsepower back-geared motor running at 1120 revolutions per minute.

Provision is also made for the removal of the refuse material by means of conveyers from the different mills. All sawdust is conveyed directly to the boiler room and automatically fired. From the band mills and the edgers the slabs are carried to slasher saws, which are saws.

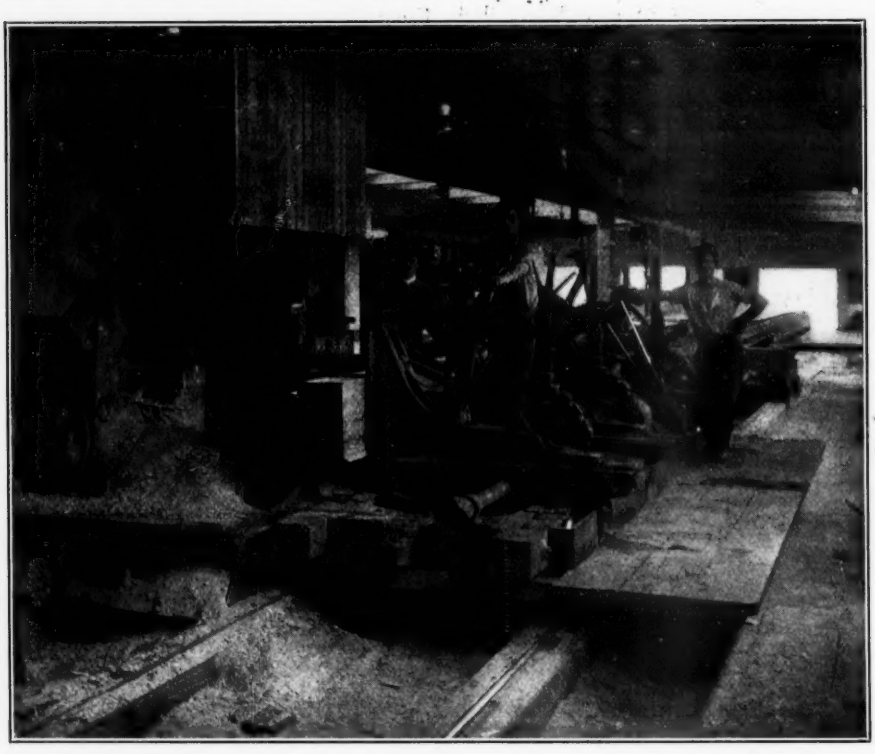


FIG. 3. RIGHT-HAND BAND MILL DRIVEN BY 150-HORSEPOWER MOTOR

mounted on a shaft and 4 feet apart. From the slashers the 4-foot lengths are taken, together with other refuse from the mills with the exception of the sawdust, by conveyers to a machine known as a "hog." A certain percentage of this material, however, before reaching the hog is taken out of the conveyer by hand and loaded into cars for shipment to paper manufacturers. This pulp wood is used in the manufacture of paper and must have a length of 16 inches and over. The balance of the refuse is cut into chips by the hog, from which it is dumped into cars for shipment to nearby tanneries.

The slasher is operated by a 30-horsepower, 840-revolutions-per-minute motor, which also operates six conveyer chains, each 100 feet in length. The hog is driven by a 75-horsepower motor, 690-revolutions per minute, direct-connected. It has a large rotating element weighing approximately 2000 pounds, which carries 24 knives on a diameter of 60 inches. Owing to the weight of the moving element of the hog, the starting conditions are particularly severe, but the motor, which is of the slip-ring type, brings the machine up to speed quickly without undue overload. The main refuse conveyer for carrying refuse to the boiler room is operated by a 10-horsepower, 1120-revolutions-per-minute motor.

The woodworking equipment was supplied very largely by Clarke Brothers, and the motor equipment by the Westinghouse Electric and Manufacturing Company.

The Small Fan in the Engine Room

By W. H. Wakeman

Many engine rooms are too hot to be comfortable, because no attention is paid to proper ventilation, but by locating a small fan near a desk where the daily log is written, or if it can be moved from place to place in order to be near various repair jobs, it will add much to the comfort of those employed in this work, not only by admitting fresh air, but by keeping that which is already in the room from stagnation.

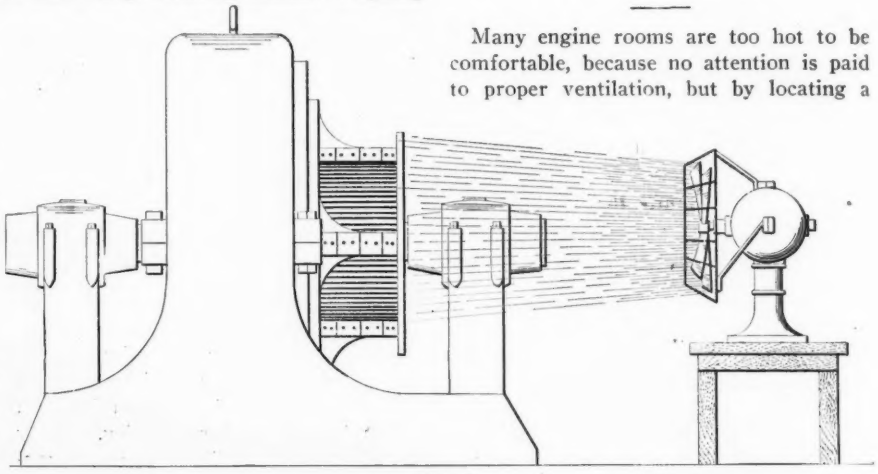


FIG. 1

The brushes and commutator on one of my dynamos were running quite warm, and it was not practical to shut down or reduce the load. A small fan was located where it could circulate air rapidly over these parts, as shown in Fig. 1. By holding a hand in this air blast, not only near the fan but also after it had passed the dynamo, the difference in temperature was plainly felt, thus showing that much heat was dissipated by the swiftly moving air. In a short time the brush holders were as cool as before the machine was started. This is also a very good plan for blowing out dust that accumulates in the armature and field coils of dynamos and motors.

The success of this experiment suggested similar action when a main bearing began to heat and the result was very satisfactory. This is illustrated in Fig. 2, and it is much cleaner and better than the barbarous plan of turning a stream of water on a bearing that is warmer than it ought to be.

As the air blast carried off much heat in these two cases, why will it not do good work in the case of a gas engine, as illustrated in Fig. 3? It might not be sufficient for hard service, but it is worth trying, as it will save some or all of the

expense of water for the jacket, and this is a comparatively large item in some cases.

Fig. 4 illustrates a fan blowing air on the cylinder of an air compressor, thus preventing an excessive accumulation of heat where it is not wanted. There are other places where the air blast from a portable fan will facilitate operations, or render disagreeable work more comfortable, the details of which will occur to those engaged in such work after considering the foregoing incidents and suggestions.

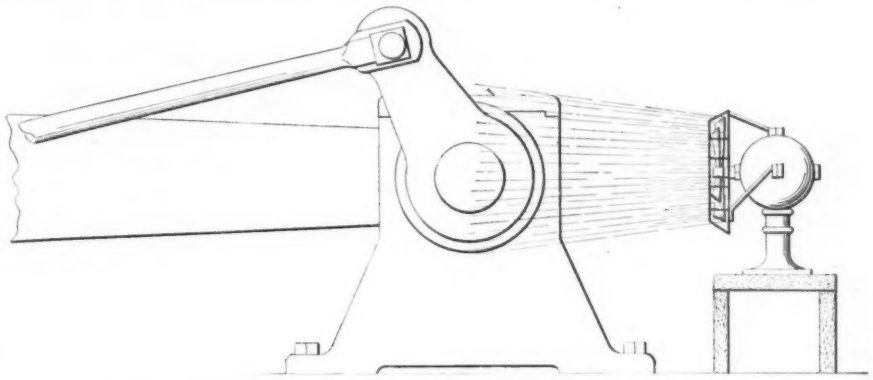


FIG. 2

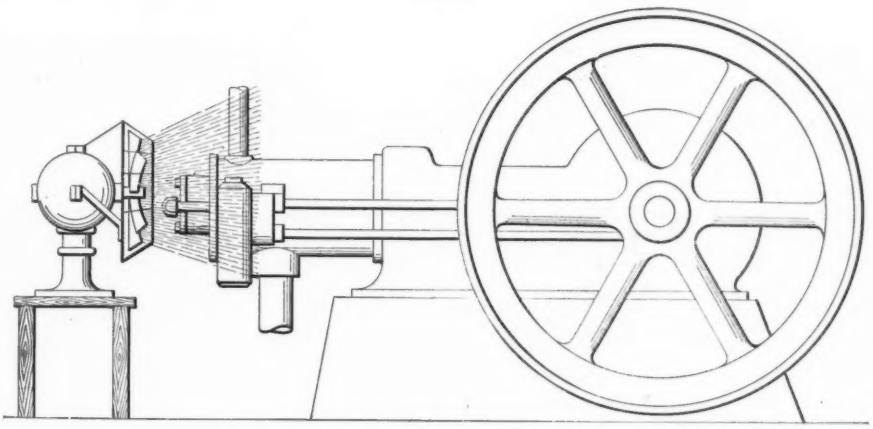


FIG. 3

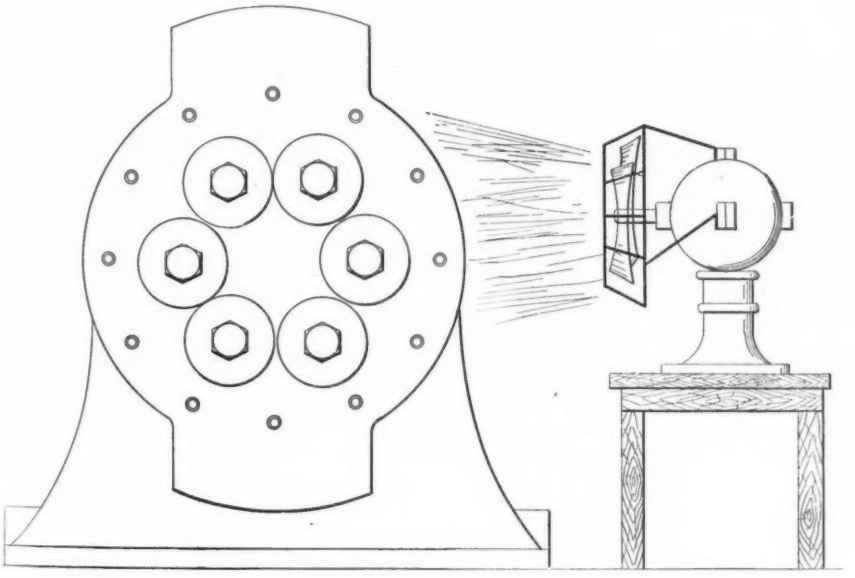


FIG. 4

The Operator for the Gas Producer

By J. C. Miller

The discussion that has been going on as to what grade of man is required to secure the best results from the gas producer, is very interesting to the writer and should be to anyone else who has started and operated different types of gas producer and had to secure satisfactory results from them.

The one element that must be considered above all others in gas-producer operation is reliability. Economy, ease of operation, adaptability to load and other good qualities fade into nothingness when compared with reliability. Reliability in a producer plant means, first, an ability to furnish a regular supply of cool gas of a uniform quality; second, a gas of uniform heat value regardless of the quantity supplied; third, means for cooling, removing ashes and clinkers and supplying water as required, without affecting the heat value or quantity of gas furnished.

The writer is convinced by his experience that more judgment is necessary for the proper operation of the gas producer than for that of the steam boiler. In the case of the steam plant, water must be kept at a certain level; the gage glass shows this. Pressure must be maintained; the steam gage shows what it is. Inspection of the fire may be made at any time by opening the fire door; ashes may be removed and the fire cleaned when the fireman wishes and while the plant is operating. With the boiler there is a guide for all operations and judgment is needed only in emergencies. The gas producer is a different proposition. The operations are concealed; no good view can be had of the fire; the heat value of the gas is a matter of judgment, and good judgment, too. No continuous record is at hand to guide. Gas-storage capacity is small, so the producer must be constantly in good condition to secure quick response to demands. The quality of the gas is affected by the depth of the fire, the steam supply, the demand, and atmospheric conditions, all of which are points upon which judgment must be exercised.

Salesmen's Unwise Claims

The salesman often tells the buyer that he can put in a charge of coal once or twice a day and leave the producer to its own care. This is untrue in practice and the claim is not necessary in order to sell the goods. If the demand for gas is uneven or if the heat in furnaces is to be maintained at constant value, attention at frequent intervals is necessary.

The gas-producer plant has no place for a cheap operator without judgment. The engineer of a steam plant will make the best man for it, if he comes with no prejudice. He will lead the novice in power-plant practice by all he has learned previously in boiler and fire management. If he operates a gas engine in combination he will find more place for judgment than in his steam plant.

Steam applied to the piston of an engine will produce motion and the engine will operate. With the gas engine it is different. Several operations must take place in perfect unison in order to make the engine operate and more things are liable to get out of order. Better judgment is needed to operate a gas-engine plant than a steam plant.

Some Recent Steam Engine Failures

Description of a Number of Interesting Accidents Which Were Reported by the Engineering Expert of a Casualty Company

BY HOWARD S. KNOWLTON

Four or five months ago, in POWER AND THE ENGINEER, a number of steam-engine failures were presented, as drawn from the practice of one of the large accident-insurance companies during the past two or three years. A number of additional failures have since come to hand from the same source. Every casualty company dealing with accidents to power-plant machinery has exceptional opportunities to point out instances of poor practice and their remedies, and these practical considerations are independent of the locality in which the machinery is operated, in great measure. In the following notes upon some typical accidents to steam engines the report of the casualty company's engineer has been followed closely, and a few sketches have been included by way of illustration.

CONDENSER WATER BACKS UP INTO CYLINDER

One notable failure was of an engine of the cross-compound type, with cylinders 26½x40¼x54 inches, making 40 revolutions per minute with a boiler pressure of 80 pounds. Each cylinder had a slide valve at each end, and gridiron expansion valves of automatic type were used on the high-pressure cylinder. At the time of the accident the engine began to gain speed suddenly. The engineer shut the stop valve and the speed fell, but before motion ceased the bedplate on the low-pressure side broke and the crank pedestal was forced forward ½ inch. The piston was driven 1/16 inch up the cone of the rod, the cotter bent and the crank pin loosened. The speed increase was due to the governor losing control of the valves through the slackening of a set screw. The damage was caused by water in the condenser, as the engineer did not shut off the injection or break the vacuum. The speed was so slow that the water was forced into the condenser more rapidly than it was removed by the air pump, and thence flowed back into the cylinder through the exhaust pipe. An automatic cutoff gear and a vacuum breaker have since been installed at the suggestion of the casualty company.

CRACK IN CRANK PIN

In another case an accident occurred to a horizontal tandem-compound engine with cylinders 20x43x54 inches, normal speed 52 revolutions per minute, and a boiler pressure of 125 pounds. The crank was of forged wrought iron or steel supposed to be shrunk upon the shank of the crank pin, which was also secured by a key. The journal of the pin was 9½ inches long by 6 11/16 inches in diameter, and the shank 7¾ inches long by 7½ inches in diameter; and between the two was a collar, as illustrated in Fig. 1. As far as was known the pin was put in when the engine was built, but it was not known when the key was put in. The large end of the connecting rod began to run warm and to knock, and red oil began to ooze out of the crank eye around the pin and key. A faint crack was noticed on the end of the pin at the back of the crank. The key was taken out, refitted and driven up tight; the bleeding continued and the crack extended until it reached entirely across the end of the pin.

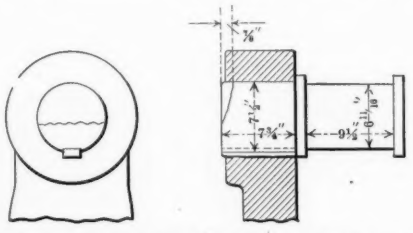


FIG. 1. CRACK IN SHANK OF CRANK PIN

As the pin was evidently slack and moving, it was thought best to take the pin out for examination, particularly as the extent of the crack was unknown. After some trouble and heating the crank eye with gas, this was done. It was then found that the shank of the pin had been bearing at the back and front at opposite ends of the diameter, lying in the plane of the line of centers of the engine, and that it had been moving and had worn the crank eye oval. A wedge-shaped piece had also been split off the end of the shank. The only probable solution was that the pin was turned out of an old crank shaft with a crack in it, which gradually extended when the pin began to get slack, and the pressure of the crank eye upon it became concentrated on the semi-detached piece.

PISTON BENT BY CLOSING STOP VALVE BEFORE BREAKING VACUUM

A case of piston bending occurred in a high-speed inverted triple-expansion engine making 383 revolutions per minute, with 14x20½x30x14-inch cylinders. The engine was direct-connected to a dynamo. The exhaust steam from the engine was led through a valve in the exhaust pipe to a jet condenser, or when this valve was closed, through an automatic atmospheric-relief valve to the outer air. The condenser was cleared by a pair of Edwards air pumps driven by an electric motor, the latter receiving current from the dynamo driven by the engine. Water for the condenser was taken from a pond whose surface was about 15 feet 7 inches below the centers of the cylinders. Thus, if the air pumps did not clear the condenser, the water from the pond would be forced into the low-pressure cylinder if the pressure in it were less than 8 pounds absolute per square inch.

The usual practice of shutting down was to close first the engine stop valve and then the valve in the exhaust pipe to shut off the condenser. On the evening of the breakdown this practice was followed, but the engine, instead of coming gradually to a standstill as usual, stopped suddenly as the engineer was about to close the valve in the exhaust pipe. The cause of the stoppage was an inrush of water from the condenser into the low-pressure cylinder, which bent the piston and stretched the bolts in both ends of the connecting rod. The accident was caused by the closing of the engine stop valve before the vacuum was broken. If the engineer had destroyed the vacuum, either by closing the injection valve, or shutting off the condenser, or by opening the atmospheric valve before touching the engine stop valve, the accident would not have happened.

IMPERFECT WELD IN PISTON ROD

An accident occurred to a 1500-horse-power horizontal tandem-compound engine, the normal speed of the engine being 39 revolutions per minute with a boiler pressure of about 100 pounds per square inch. The low-pressure cylinders were next the cranks. The piston rods, 5¾ inches in diameter, were cottered into the crossheads at the front ends and swelled at the back ends to receive the pistons. The enlarged ends were also bored to receive the front ends of the high-pressure piston rods, which were secured by the same cotters as the low-pressure pistons. One morning the rod of the low-pressure cylinder on one side broke without warning, about 22 inches in front of the piston. The cover at the back end of the cylinder was driven off, leaving pieces of the flange upon some of the studs. The other studs were broken. The high-pres-

sure cylinder was split at the back in two places, and a piece measuring about 20x18 inches was knocked out of the side. The back cover was broken in pieces, which were blown against the end of the engine house, damaging the wall. Curiously enough, the pistons were undamaged save for the breaking of the rings. The rod was of steel and had been welded four years ago on account of a crack at the cotter hole at the back end. The appearance of the fractured surface showed that

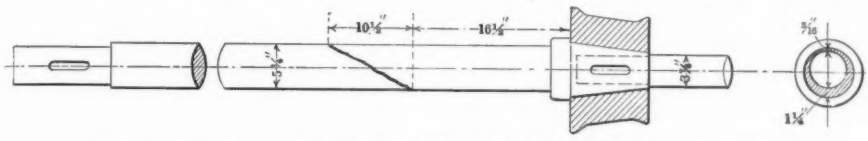


FIG. 2. BREAK IN LOW-PRESSURE PISTON ROD DUE TO IMPERFECT WELD

the weld had been very imperfect; the two pieces broken had been joined only upon the surface.

Crank Shaft Breaks Repeatedly

A case of shaft breakage occurred in a high-speed inverted vertical noncondensing double-acting two-crank engine, cylinders 9x15½x8 inches, direct-connected to a dynamo and running 425 revolutions per minute, the boiler pressure being 140 pounds per square inch. The engines were installed in 1900. In 1905 the crank shaft was found to be slightly bent and was replaced, the old shaft being kept as a spare after being trued up by skimming up the bearings in a lathe. In 1907, after having run less than two years, the new shaft broke through the web of the crank next the dynamo, and a third shaft was ordered, the spare shaft first mentioned being used to keep the engine in service. The cause of the breakage was not ascertained. The company's inspector reported the shaft to be hard and brittle, but the makers of the engine stated that it was made from their standard quality of steel, of about 32 tons tensile strength. They considered the breakage to have been caused by the bearings being out of line or level, and advised that these bearings should be lined and adjusted before a new shaft should be put in. The dynamo armature was accordingly lifted, the brasses were relined with white metal and leveled, and the new shaft bedded upon them. Eight weeks later the new shaft broke in the same place as the old one. The two surfaces of the fracture were quite close when the inspector saw them, but when the shaft was taken out two patches of white metal were found imbedded in the crack. The makers of the engine again attributed the fracture to the bearings being out of line, but the casualty company's engineer decided that it came from improper treatment of the steel during manufacture.

A test gave an ultimate strength of 34.48 tons per square inch, an elongation of 28.5 per cent. in 2 inches, with a reduction of area of 41.56 per cent. The carbon was 0.36 per cent. The appearance of the fractured surfaces indicated overheating of the steel, though it was possible that with a speed of 425 revolutions per minute it might have been the result of excessive stress produced by cumulative vibrations synchronizing with the period of the engine.

Crack in Valve Chest

Another accident occurred to a horizontal triple-expansion engine installed in 1902. The high-pressure piston was 20 inches in diameter and one low-pressure piston, 37 inches in diameter, was coupled to the crank pin of the other, the cranks being set at right angles to one another. The stroke of all the pistons was 60 inches, and the speed about 62 revolutions per minute. The boiler pressure was 160 pounds per square inch. The high-pressure cylinder consisted of a plain cast-iron liner shrunk into an outer casing, with which were cast Corliss valve boxes and connecting passages. Longitudinal and transverse sections taken through the middle of the cylinder are shown in Fig. 3. After working five years, steam was observed coming from below the lagging, and on removing the latter a crack 31 inches long was found as indicated at *A A*. The weakness of the design, notwithstanding the cross ribs which stiffen the flat top of the steam passage, is self-evident, and the fracture is not surprising. The danger of admitting steam at high pressures into cylinders and valve chests of weak design cannot be overestimated. In the case described a new cylinder was the only remedy, and while its construction was pending the old cylinder was kept in operation by strengthening the flat surfaces by clamps and staybolts.

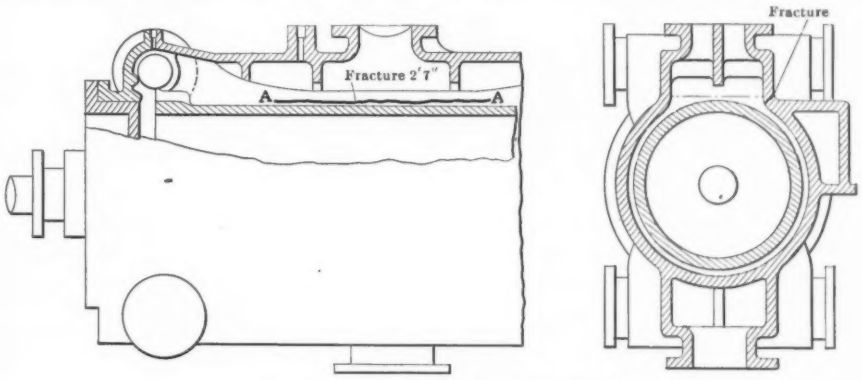


FIG. 3. LONG CRACK IN VALVE CHEST

Disadvantages of Rectangular Castings

An important case of cylinder blowout was encountered in the instance of an engine, with 23x33x42-inch cylinders, making 32 revolutions per minute under 120 pounds boiler pressure. A new low-pressure cylinder was fitted to this engine which was a rather old machine. The cylinder was a casting about 8 feet long and of rectangular cross-section 25½ inches wide and 15 inches deep, the back, front and sides being flat and varying in thickness from ¾ to ⅞ inch. It was divided vertically by a flat portion of the same thickness into two passages, one next the cylinder of about 24x4½ inches internal measurement, which received the steam from the high-pressure cylinder and led it to the top and bottom steam valves, the other being farther from the cylinder, 24x7¼ inches, for leading the steam from the top and bottom exhaust valves to the exhaust pipe and condenser.

The partition was stayed to the front and back of the casting by ribs near the top and bottom, but a central portion of more than 3 feet was unstayed. The pressure in the steam passage was about 25 pounds absolute, and the pressure in the exhaust passage about 3 pounds absolute, so that the unbalanced pressure on the partition was about 22 pounds per square inch, and on the front of the casting about 12 pounds per square inch. During the temporary absence of the engineer a piece 38x24 inches was blown out of the partition dividing the steam from the exhaust passage, and a corresponding piece of nearly the same size was blown out of the front wall of the casting dividing the exhaust passage from the air. The vertical cracks in both occurred at the junctions of the flat surfaces with the side walls of the box, and extended the full length of the central portion unstiffened by the ribs. All were old, and those in the partition had worked their way through the full thickness of the metal for a hight of about 18 inches on each side. Those in the outer wall had not penetrated very deeply. The cause was evidently fatigue due to panting under variations of pressure and possibly under excessive pressure when starting the engine. The final fracture was brought about by the key which fixed the lever on the end of the bottom steam-valve

spindle becoming loose and falling out, leaving the valve stationary and, as it happened, covering the port, so that the steam discharged from the lower end of the cylinder could not get into the lower end of the condensing cylinder, but remained in the cracked casting, practically doubling the pressure in it. The accident illustrated the great disadvantage in using rectangular flat-sided castings for holding steam. The existence of the cracks in the partition and of the incipient cracks in the outer wall, all running vertically up the junctions of these surfaces with the flat sides of the box, prove the inferior design of this form of cylinder even when stressed within the limits of ordinary practice, while the accidental loosening of a key is but one of the many other accidents which may occasion dangerous rises of pressure in the valve chests of the low-pressure cylinders of compound engines.

A Distorted Cylinder

Another engine to suffer accident was a vertical triple-expansion unit with 20¾x33x53-inch cylinders having a 36-inch stroke, running at 110 revolutions per minute and supplied with superheated steam at a pressure of 180 pounds per square inch by water-tube boilers. The engine was placed in service in the summer of 1907, and almost at once the high-pressure piston rings began to break and the piston to show signs of scoring. The trouble was attributed to priming, which was admitted to have occurred. The piston was taken out, filed smooth, and fitted with new rings. Later on these broke, and it was noticed that the piston and cylinder were scored at each end of a diameter and not all around the circumference. To shorten the stoppage in case of the rings again breaking a complete new piston was made, and to lessen the risk of binding the allowance between the diameter of the cylinder and piston was increased to 0.0265 inch. This piston was installed and appeared to work well. A little later the cylinder cover was taken off to test the tightness of the valves. When the steam was turned onto the valve chests, leakage was observed near the lower end of the cylinder bore, and a circumferential crack 8½ inches long was discovered. The cylinder was found to be scored in the vicinity of the crack and diametrically opposite it. The corresponding parts of the piston were also deeply grooved. Evidently the cylinder had changed its circular form when heated and became oval, the allowance made on the piston not being sufficient to compensate for its own expansion and for the deformation of the cylinder barrel. This allowance was increased to 0.04 inch when the new cylinder was put in. The deformation is readily accounted for, as the cylinder casting was very complex, containing not only the cylinder barrel, but four chests for drop valves, steam and exhaust nozzles and brackets for attachment to standards to which it was bolted. The position of the crack was just below the top of the bottom steam-valve box. Whether it was the result of heating or of stresses set up during the cooling of the casting is uncertain, though the former is probably the cause, for such circumferential cracks are not uncommon when there has been "seizing" between cylinder and piston.

In another case the horizontal low-pressure cylinder of a compound engine was found grooved and cracked in the same way after working for a short time with a piston 0.012 inch in diameter less than itself. The grooving was clearly traceable to the distortion of the cylinder bore, since it occurred in two places diametrically opposite each other. Similar circumferential cracks were found cutting through the grooves scored in the liner of the cylinder of an internal-combustion engine where the piston had evidently been too large, and having run hot had seized the cylinder wall. In this case the cracks had clearly not been the result of cooling strains, as the liner was a simple pipe. These cases indicate that in turning pistons for cylinders of complex shape, allowance must be made not only for expansion due to the heat of the working fluid, but also for the distortion resulting from the unequal expansion of unsymmetrical shapes.

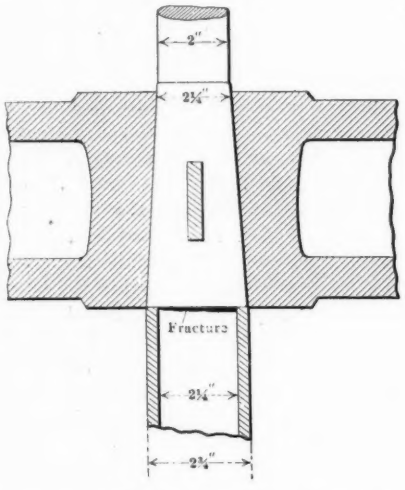


FIG. 4. FRACTURE IN PISTON ROD OF AIR PUMP.

Fractures of Rod and Beam

A case of rod fracture occurred in an air pump run in connection with a horizontal cross-compound engine making 73 revolutions per minute. The air pump, single-acting, vertical, 19x21 inches, was driven from the low-pressure piston-rod crosshead by links, bell-crank levers and links to the pump crosshead. The crosshead was cottered into a cone upon the rod, as shown in Fig. 4, and the rod was guided below the crosshead by the gland in the air-pump cover and above by a brass bushing in a cross arm fixed to the engine bedplate, and not by the method of slide blocks on the crosshead arms. The upper part of the rod which passed through the guide bushing was 2 inches in diameter. The conical part on which the crosshead was cottered tapered from 2¼ inches at the upper end to 2¾ inches at the lower end, and the part below the crosshead was reduced to 2¼ inches in diameter, the shoulder at the junction of this part with the lower end of the cone being square. The lower part of the rod was sheathed with brass ⅜ inch thick. The rod broke at the abrupt change of diameter at the lower end of the cone where the brass sheathing began. The appearance of the surfaces of the fracture showed that the rod had been cracked nearly half way through before the final break. The fracture was caused by the bending stress produced by the horizontal component of the diagonal thrust of the links connecting the bell-crank levers to the crosshead, intensified by the abrupt change of section. Air-pump rods guided like this one, above and below the crosshead, but not by the crosshead, frequently break, but generally through the cotter hole, the hole being usually driven, as in this case, in a plane passing through the center line of the engine, so that the bending stress is concentrated at the edge of the cotter hole where there is little material to resist it. This is a typical case.

Another case of a broken beam may be cited, not as an illustration of the effect of overloading, but by way of a hint to those who have engines connected by shafting or gearing to other engines or turbines. In this case the engine, a condensing beam unit, with cylinders 28 inches diameter by 48 inches stroke, running at 33 revolutions per minute, was coupled to a water wheel by shafting and gearing. On the occasion of the breakdown, the water wheel was, as usual, started first, and immediately the engine beam broke off short between the air-pump gudgeon and the main center. Whether the breakage occurred before the piston had completed its first upstroke or immediately after the driver had begun to open the stop valve to admit steam was not known, but it was clear that the water caused the trouble—presumably accumulation of condensed steam leakage on the top of the piston. There were no safety valves on the cylinder.

Wherever there is a line shaft attention should be given to keeping the shaft clean. Aside from other considerations an accumulation of dust and grease on the shaft is an added fire hazard. The easiest way to prevent dirt and dust from collecting is to provide each shaft with loosely fitting disks of strawboard, leather or other material, which are free to whirl, and as the shaft rotates, will travel back and forth preventing any deposit or accumulation of dust or oil.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Dimensions and Capacity of Rectangular Tanks

While tables are published showing the capacity, in gallons, of cylindrical tanks of standard size, the same is not true of rectangular tanks, for the possible combinations with three variables is so great that a complete table would be both cumbersome to handle and difficult to use.

The accompanying chart is designed to show graphically the dimensions of tanks having capacities up to 1500 gallons and multiples thereof. It being very easy in case the tank is of such dimensions as to contain over 1500 gallons, to halve one or two of the dimensions and multiply the capacity by two or four, as the case may be, or to find the capacity for 1 foot in hight and multiply by the hight. The chart may also be used where the capacity is given and the size is desired, or where the capacity and one or two of the dimensions are given and others are required.

The two following examples show how the chart is applied: What is the capacity in gallons of a tank 4x9x2½ feet? Starting with 2½ feet on the right-hand scale, read up to the line designated as 4 feet, then across to the 9-foot line and down to 675 gallons.

What is the hight of a tank 6x9 feet, to contain 1200 gallons? Starting at the 1200-gallons point, read up to 6 feet, then across to 9 feet and down to 3 feet.

W. L. DURAND.

Brooklyn, N. Y.

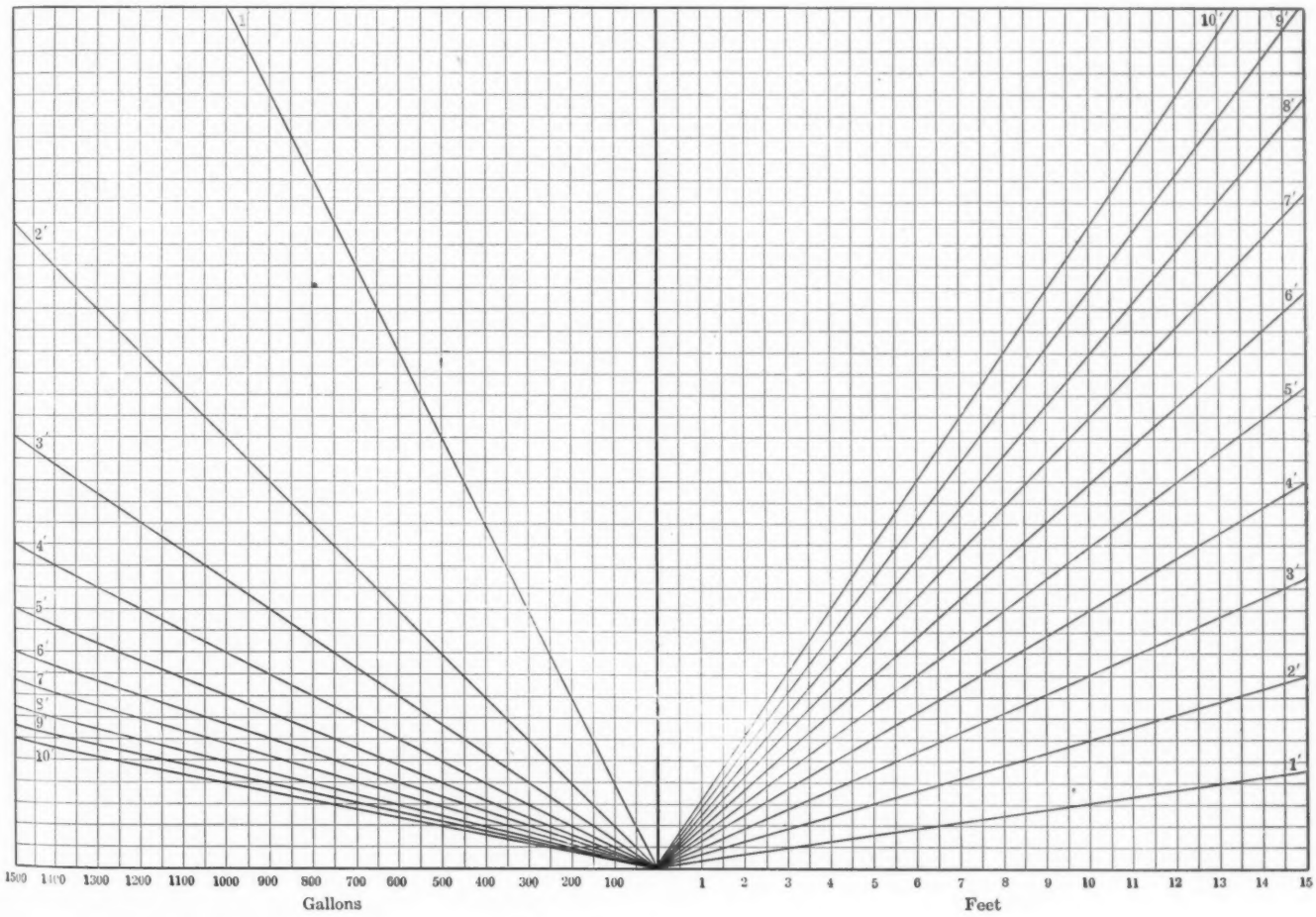


CHART FOR DETERMINING THE DIMENSIONS AND CAPACITY OF RECTANGULAR TANKS

To Handle Wood Economically

We are burning from 600 to 800 cords of wood per month. It is delivered by contract, as near the plant as possible to pile it, and we find that the rehandling from the pile to the boilers is an item of considerable expense. The plant is located on the side of a mountain, the inclination of which, at that point, is between 40 and 45 degrees.

I hope that some of the readers will make suggestions as to the economic handling of such an amount of wood, from piles on the mountain side to the boiler room, where our space allows only six cords to be piled at a time. The wood is cut 30 inches long.

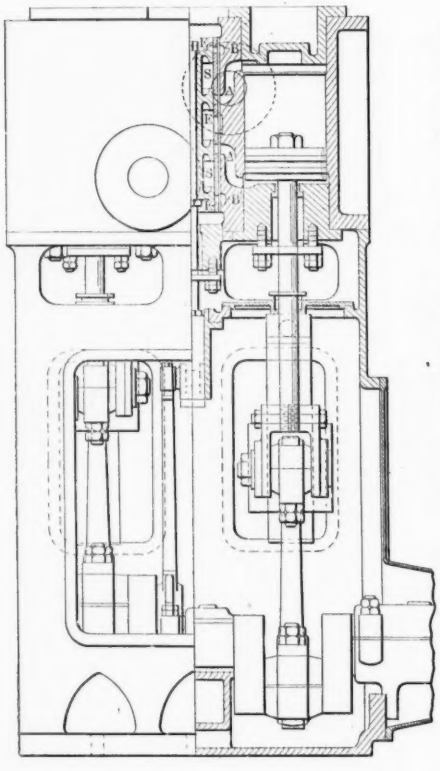
I. B. SUTTON.

Yzabal, Mexico.

Central Valve Engines

Having seen in a recent issue an illustration of a central-valve engine of English design, I am inclosing a sketch of an American product which has proved to be very practical. The cranks of the engine are set at 180 degrees, as shown, with the single eccentric mounted on the shaft between them. The valve travels in a removable bushing, in which the ports are accurately machined; the valve, as shown, is in its central position. The spaces *S* are in communication with the steam pipe, while the spaces *E* lead to the exhaust pipe. At *A* and *A'* are ports to the right-hand cylinder, while *B* and *B'* lead to the left-hand cylinder.

The action of the valve is similar to any slide or piston valve, and if displaced upward an amount equal to the steam lap, steam will be admitted on one side through the port *A'* and on the other side through the port *B*, the exhausts at the same time being through ports *A* and *B'*, respectively. Cutoff and compression follow on the return motion of the valve.



AN AMERICAN CENTRAL-VALVE ENGINE

In practice the steam lap is a trifle greater for the top end of the cylinders and the exhaust lap greater for the bottom end. This in a measure offsets the irregularity due to the connecting rod and gives an earlier cutoff at the top and more compression at the bottom, as is customary in vertical engines.

H. L. Dean.

Hyde Park, Mass.

The Centrifugal Pump

In the December 1 issue, George P. Pearce takes issue with my statement in a previous number that when the discharge opening of a centrifugal pump is closed no further power is required by the water within the impeller after having been brought up to speed. As pointed out in the original article, a certain amount of

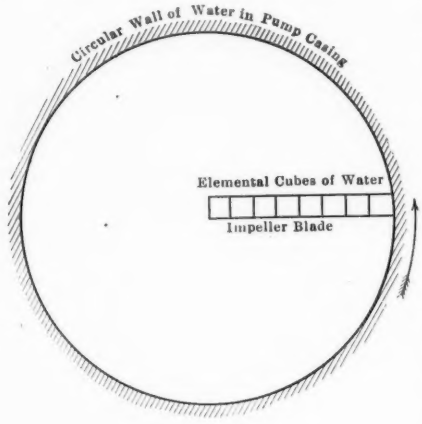


FIG. 1

power would still be required to overcome friction and to supply the energy wasted in eddies, but, as I understand Mr. Pearce, that is not in question and need not be discussed.

Mr. Pearce's position, and that of a number of other contributors, is indicated in the following paragraph from his letter:

"Surely a centrifugal pump running with suction open and discharge closed is operating under a considerable load, for the shape of the impeller is such that it is constantly trying to throw more water into the outer casing, and as this is impossible then it is forcing its way through the water against the resistance due to the pressure built up in the casing, due to its circumferential velocity."

No power or expenditure of energy is required to withstand a pressure as long as there is no flow, in the same way that no mechanical work is performed by a man carrying a hodful of brick on a level walk. The man does work in a mechanical sense only when he begins to climb the ladder and to create a flow of bricks from a lower to a higher level.

To put the case more graphically, consider Fig. 1. Let the radial line be one of the impellers of a centrifugal pump, and let the circle at its extremity be a solid circular wall of water in the casing of the pump. The little squares on the radial line represent cubes of water. Now, when the impeller is rotated the cube on the end will press outward by reason of the fact that it is continually constrained to change its direction of motion, and will exert a pressure upon the circular wall of water in the casing. The next cube will similarly exert a pressure on the first cube, and so on down to the center of rotation. Each cube will try to push those ahead of it off the impeller, the result being a certain definite pressure per square inch between the outside cube and the stationary water in the casing. As long as the impeller is rotating with uniform speed, this pressure will be maintained, and if it is assumed that the whole space within the circle be filled with water, there will be uniform pressure all around the circle. If it could be made a further condition that there would be no friction between the outside cubes and the surrounding wall of water no power would be required, once the mass of water in the impeller were brought up to speed, and at the same time the pressure would be maintained.

What actually happens is that a certain amount of power is lost in skin friction in overcoming viscosity and in the production of useless eddies, both within the impeller and in the surrounding chamber, but this consumption of power never amounts to as much as the power required by the pump when delivering water. In fact, this loss of power due to friction and eddies remains, roughly the same, whether any water is being delivered or not, but an increased amount of power is required for accelerating new masses of water as soon as delivery begins.

It is probably true, as Mr. Pearce states, that the eccentric casings used with some centrifugal pumps cause an increase of the losses due to eddies. On the other hand, however, the casings of all, except the last stages of most multistage pumps, are concentric with the shaft.

Mr. Pearce also refers to the shape of

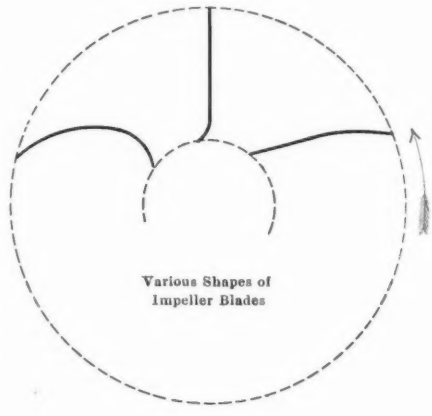


FIG. 2

the impeller being such that it is constantly trying to throw water into the casing, and he will therefore probably be surprised to learn that the blades of impellers may have different shapes, as shown in Fig. 2, and that as long as the delivery pipe is closed off these shapes have little influence upon the amount of power consumed or upon the pressure generated. As soon as flow begins, how-

ever, pumps with the different impellers exhibit different characteristics.

Mr. Pearce asks if the charts which accompanied my first letter, showing that the power required falls off as the flow is reduced by throttling the discharge, were plotted from actual tests or from theoretical formulas. They were plotted from tests and nearly all charts, wherein the power consumed by centrifugal pumps is plotted as one coördinate and water delivered as the other, show the same thing, the power consumed at no load being somewhere around a quarter or third of the power consumption at the point of maximum efficiency, upon which the nominal rated capacity of the pump is usually based.

GEORGE H. GIBSON.

New York City.

Commutator Trouble

The commutator trouble A. L. Baker mentions in a recent issue might be caused by a number of things, among which are the following: Brush position; running as it does with a weaker field than that for which the machine was designed, the brushes will probably need a greater forward lead than at normal voltage. Brush spacing; if the several sets of brushes are not spaced equally around the commutator, sparking will occur; this spacing can best be checked by aid of a strip of paper of a length equal to the commutator circumference, on which has been marked off as many equal divisions as there are brush-holder studs; the paper should be pasted to the commutator and each stud set so that the toe of the brush will come to the mark; care should be taken that the brushes all lie in line with the commutator bars. Tight brushes; every brush should be gone over to see that it fits sufficiently loose in its holder to allow the spring to press it against the commutator; dark streaks are often caused by tight brushes; on the other hand, a brush that fits too loosely in its holder will also cause trouble. Brush contact; too much care cannot be taken in sanding the brushes; a coarse paper may first be used, but the finishing touches should always be done with a very fine grade, the brush being under the tension of the spring only; smoothing should always be done in the direction of rotation. Metal bridges; after smoothing or turning off the commutator, it should be carefully examined for copper bridges across the mica strips between the bars; if these exist they should be removed; a knife blade will usually accomplish this very successfully.

If there are no errors in the design of the machine, a rigid application of the foregoing hints should produce better commutation.

EDWARD CHENEY.

Schenectady, N. Y.

Interesting Indicator Diagrams

Tracing Fig. 1, it will be noticed that both ends are joined. I have noticed several diagrams like these for five years past. None of us has been able to give the cause, although various arguments have been advanced. In the present case

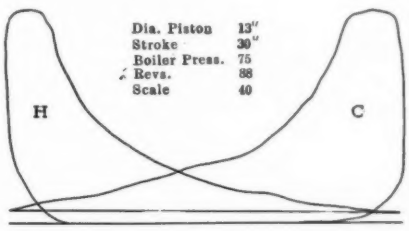


FIG. 1

the instrument was an outside-spring Tabor indicator, with Houghtaling reducing motion. The piping was ½-inch, with an angle valve at each end and there was an indicator cock between the indicator and piping. My assistant could not help making these diagrams, while I could not make one after him. I could not detect

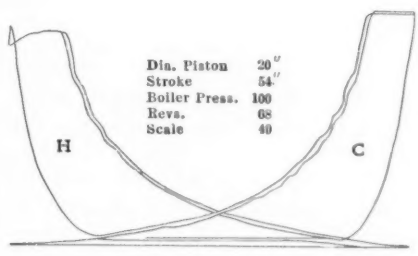


FIG. 2

what he did, nor can he explain it. These have been repeated so often that I feel satisfied that it must be due to some peculiar manipulation of the instrument. I should like to see it discussed.

The diagrams in Fig. 2 show plainly the effects of excessive and moderate compression of exhaust steam. The engine was an old one which had just been re-

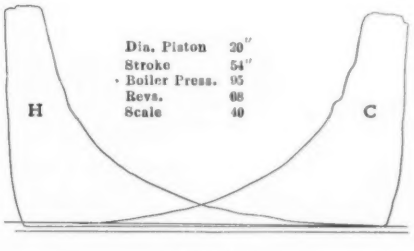


FIG. 3

fitted. The condition of the engine can be considered fair. There was a marked difference in economy of fuel and possible load to carry. As refuse (wood) was the fuel used, I have to accept this report from the owner and the engineer that such is the case. The engine ran perfectly smooth in the last condition.

In Fig. 3, as the engine was with excessive compression, it ran jerkily. As left, it ran like a clock, as the saying is. The fuel here was mixed. In the last condition very little coal was required. I am told that the saving was about two tons per week.

J. B. LATOUR.

Toronto, Can.

Graphite in Boilers

One of the jobs I had in my earlier experiences was that of boiler washer in a plant containing six 250-horsepower water-tube boilers. These boilers were washed out every six weeks. When I close up a clean boiler, I put 2 pounds of flake graphite in each drum.

When a boiler was opened up after this treatment, and the turbine cleaner run through the tubes, the scale came off very readily. By examining the side of scale which was next the tube, graphite could be seen clinging to it. The same condition was found existing in the drums.

Since I received my license and had charge of boilers, I have used this same idea and find it works fine, especially in return-tubular boilers, where the tubes are harder to clean.

FRANK WULFFEN.

Chicago, Ill.

Storage Battery Troubles

In a recent number J. M. Herwig states that he is having trouble with his storage batteries, and that the plates were buckled when he received them. If that is the case, the batteries had been charged at some time, and very probably emptied of the electrolyte without properly discharging the batteries. In placing new separators, they should be of the proper thickness, but the plates should not be scraped off to make them thinner. The plates should not have stood in the acid an appreciable length of time without charging, which should commence when the electrolyte is placed in the cell.

In reference to the batteries becoming dead, if sulphating has occurred it can be determined by the plates being lighter in color than they were originally, and pure white sulphate flakes may form over the affected parts. To remedy this the batteries should be charged for a long time at about one-fourth the normal rate. This must not be done unless it is positively known that sulphating has occurred, as low charging is harmful to batteries.

The batteries should also be examined to see that there is no deposit in the bottom of the cells. The plates should not rest on the bottom, but should be raised enough to allow room for a reasonable amount of deposit under them. Careful

examination of the connections between the batteries should be made, as a poor joint will corrode and, although the battery may be fully charged, it will be impossible to get any current.

Short-circuiting is a very prolific source of trouble. If current has been taken from only a few of the batteries instead of the complete set, it may be possible that those used most have been discharged too low. By connecting these batteries in the circuit they could be brought up and then placed in service again.

If 1.210 electrolyte is used, it should not go below 1.170 in density. When water is added, the electrolyte should be stirred with a glass tube, as the water is lighter and may remain on top.

C. A. DAVIES.

Cincinnati, O.

Some Indicator Diagrams

One feature of F. L. Johnson's article, entitled "Some Indicator Diagrams," needs to be discussed. It can hardly be denied that compression does lower the maximum output of an engine, but the

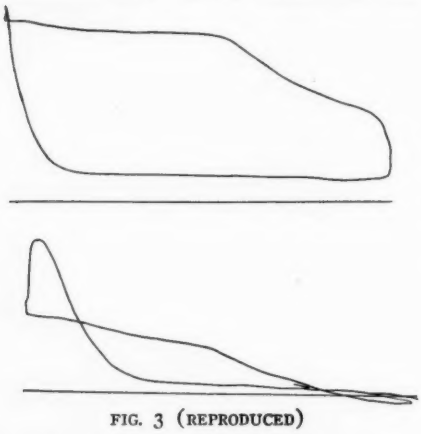


FIG. 3 (REPRODUCED)

case he cites, of an engine that was unable to carry its load after losing the vacuum, is not a fair argument against compression. The valves could have been set so as to retain the compression and a greater load could have been carried.

My idea would have been to ignore equal distribution of load between the cylinders and adjust the low-pressure cylinder cutoff equal to the ratio between the high-pressure and low-pressure cylinders. This would result in little or no drop between the high-pressure cylinder and the receiver and, although the low-pressure compression would be more than desirable, it would not rise above the admission line and make the loop (in his Fig. 3), which is negative. The loop at the other end of the card would also be eliminated, and the engine could carry a heavier load than it did under the conditions mentioned.

A. L. HOYLE.

Philadelphia, Penn.

I should like to know why the admission line leans in above the atmospheric line in Mr. Johnson's Fig. 4, which is a low-pressure card. I get practically the same result from the engines I am running.

WILLIAM HOPKINS.

Hastings, Mich.

[In the case mentioned the valve was set with little lead; the piston, therefore,

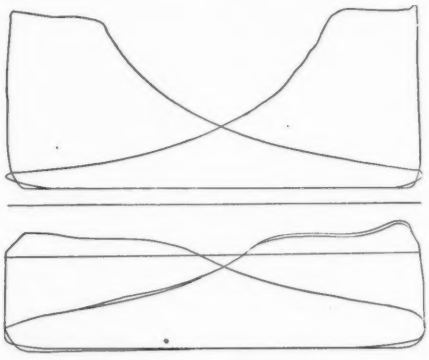


FIG. 4 (REPRODUCED)

began its stroke before the valve opened the port enough to supply the steam pressure necessary to produce a vertical line to the top of the diagram.—EDITORS.]

Location of Steam Traps

In Fig. 1 is shown the ordinary arrangement of the small trap, in connection with the steam separator, which is a fair example of the way they are found in active practice. I have observed, in

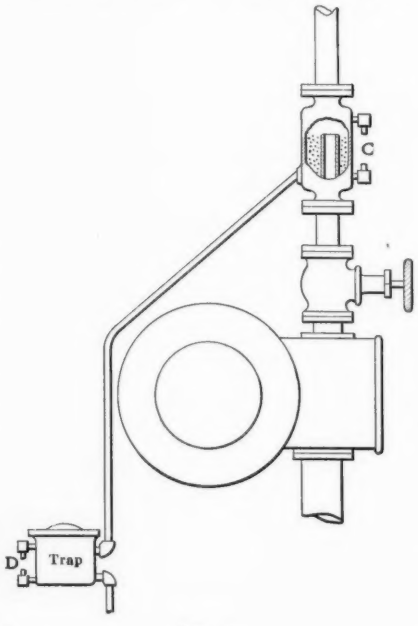


FIG. 1

connection with the placing of traps, that a long pipe of small size is run from the separator to the trap. While the trap may discharge the accumulated water quickly, the new discharge has to come through this small pipe. Some bad water wrecks have occurred from this arrangement.

A steam separator or trap should be no larger than necessary to do the work, as the two appliances present radiating surfaces which are wasteful even though they are well covered. This is no reason for selecting one so small that it will not work satisfactorily, however.

The placing of the steam drums to be drained by the trap may be so as to give the trap more advantage and facilitate the safe working of the whole system. An example is shown in Fig. 2. A better arrangement would be to have the steam drum as shown in Fig. 3; this is a much safer drum and costs no more than the other type.

The entering pipe should not be placed too close to the lower surface, as room must be allowed for the collection of the condensed water going to the trap, otherwise a counter current might be started

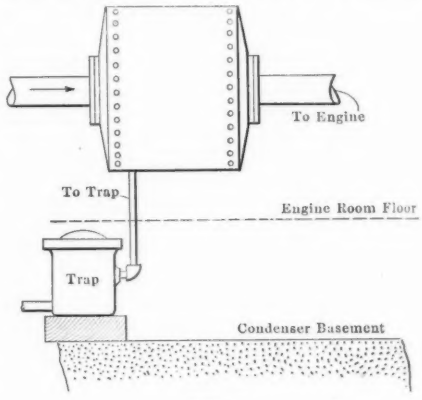


FIG. 2

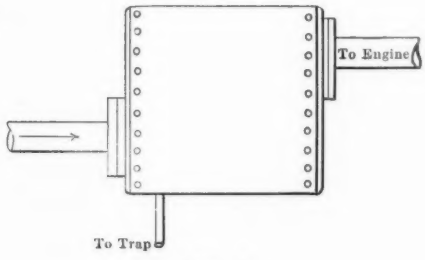


FIG. 3

and carry the water through the main to the engine.

C. R. MCGAHEY.

Lynchburg, Va.

Probable Cause of Air Compressor Explosions

On one occasion I had to look for the cause of two air-compressor explosions. The air was compressed to 17 pounds per square inch. In both cases the pipes were ruptured. Various theories were investigated, such as simple failure of the pipe, oil spray in the pipe, oil ignition at the extreme end, poor grade of oil, leaky discharge valves. The last-named offered the most plausible explanation, as air which had been compressed evidently leaked back into the cylinder where it became recompressed. This recompression will make it hotter

and hotter until it either reaches a point where radiation will take the heat faster than the temperature can rise, or the temperature will rise until the oil catches fire. The best of oils will take fire if heated enough.

F. W. Hollmann.

Baltimore, Md.

Extraneous Supervision of Power Plants

The recent quotation from a pamphlet sent out by the Engineering Supervision Company, of New York, and which Power saw fit to comment upon editorially in the December 29 number, needs more than a passing glance.

The statement made in reference to engineers being led astray by ambitious agents to the extent of receiving from 10 to 50 per cent. of the cost of work done and possibly of supplies purchased is charitable to the engineer, because he has been led by the ambitious agent. Such a statement is an insult not alone to the engineer, but also the agents. A wide experience with engineers and supply agents, combined with a practical experience of more than 20 years, forces me to state that the author of the pamphlet in question should quickly join the famed Ananias club. The statement that more than one-half of the plants are afflicted by such practice is most absurd and shows conclusively the attempt of the company to belittle the engineer in the eyes of his employer simply to gain the business they seek. Such tactics are contemptible and beneath the consideration of any fair-minded man. A concern which tries to secure business by any such methods is beneath the consideration of business men, who readily recognize the despicable arguments as being in keeping with some business firms which try to injure competitors by just such tactics.

Any concern which feels that it is not being used right by the engineer has the privilege of making a change at any time, and while there may be some engineers who are out for graft, the percentage is far from the 50 per cent. mark referred to in the circular. The practice may have been in vogue in years past, but today the engineer realizes that the better the results produced by himself the more valuable his services are. He knows this because he sees his fellow associates being elevated to higher stations, and while he is looking for advancement he knows full well it cannot be attained by following up the methods referred to.

Agents who have meritorious articles for sale are able to make good without trying to bribe the engineer. They realize how impossible it would be to do it, for their association with engineers has educated them to the realization that engineers are as honest a body of men as exists in the world today. An agent will hesitate before trying to sell a worthless article by any such methods, for he fully realizes that the law is waiting for him; he also realizes that a sale made under such conditions means that he can control the business only until some other man like himself underbids him. The cost to a firm conducting business under the specified conditions is beyond recompense where an article of any worth is sold, and the sale of an unworthy article is tabooed, as it would work a serious injury to the man recommending the purchase.

The attempt to belittle the competency of engineers by referring to them as non-technical, is somewhat modified by reference to their practical knowledge received through hard knocks.

Experience has told the employer that the man who has received practical education is the man to employ, if results are desired. Men of this class have their minds broadened by the world's greatest teacher. While they have no sheepskin to show that they graduated from some engineering college, they are in the large majority capable of giving engineering advice about the installation and operation of plants that will be worth more than that given by the technical man without practical experience. Practical experience is only gained by the work required in actual operation of a plant. It cannot be obtained by casual observation, or from a few days spent now and then in making some test. The president of one of the largest technical schools in the world once said that they did not turn out engineers, but simply prepared them, and out of the graduates not 50 per cent. ever became engineers. There is good reason for the above statement, for unless a man has an aptitude for engineering he will never be a success, whether he be college bred or practical.

The technically educated man has an advantage if he will only improve it. To do so he must of necessity start at the bottom of the ladder and work his way through the hard school of practical experience and with the advantage of his early training he will reach the goal far in advance of his less fortunate brother and be a far better man, provided he is adapted for an engineer's life. Such a man will be able to give to his employer the very best there is, but until technical men are willing to start in a menial position and work their way up, the present type of practical man, who has some technical education obtained by home study, by absorption from the mechanical press and through the engineering associations, will prove far more efficient. Possibly a little more coöperation on the part of an employer, by the devotion of time to consider the problems that confront his engineer, would be profitable.

The proposed scheme of supervision would lead to the complete control of the various plants. As the pamphlet has decidedly stated that more than one-half of the engineers are grafters, it might not be amiss to suppose the supervisors to be slightly affected along the same line. It is a possibility so to supervise that the employing firm would in a short space of time be forced to expend a large sum to bring the plant back to its past efficiency. It would make no difference to the supervisors, as they would have theirs and that is all they are looking for. It is no charitable game, just business which they are trying to obtain by false representation. It is a serious proposition to be considered by engineers in general and also by business firms before accepting any proposals from such a concern. The engineer will be forced to lower his station in life to that of a mere automaton. His recompense for a like service will be less than the common laborer gets. The business firm which enters into a contract with such a company will be badly stung and the end will be a return to present methods. A competent engineer with coöperation on the part of the employer makes a combination that cannot be beaten.

T. N. Kelsey.

Lowell, Mass.

What Reversed the Polarity

In answer to the recent inquiry under the above heading the writer wishes to state that he has had the same experience on three occasions in operating a 75-kilowatt DeLaval steam-turbine dynamo set, consisting of two 37½-kilowatt 125-volt generators connected to a three-wire system, for the operation of lights at 110 volts and a motor at 220 volts. In each case the trouble manifested itself on attempting to start the unit in the morning.

I therefore concluded that the polarity was reversed in shutting down, due to a poor connection in the armature or field circuit of one machine, which caused the voltage to drop more rapidly on this machine than on the other. With any other motors running, or any other apparatus on the 220-volt leads, the machine with the lower voltage would naturally be reversed.

After three early morning calls to get this machine to generate correctly, I decided to supply the field windings of both machines from one of them, and I have had no trouble from this cause since. As more than two years has elapsed since this experience, I feel that it is a permanent remedy for the trouble cited.

James D. Cartin.

Watertown, N. Y.

The Plunger Hydraulic Elevator

Operation of the Valves in the "Standard" Plunger Freight Elevator Clearly Explained; How the Lifting Cylinder is Designed

BY WILLIAM BAXTER, JR.

For the operation of freight elevators the Standard Plunger Elevator Company provides simple hand-rope-operated valves. These valves are made to be moved by a lever if the car speed is very low, by single-geared rack and pinion for moderate speed and by a double-geared rack and pinion for high velocity; they are also of the balanced and unbalanced types. An

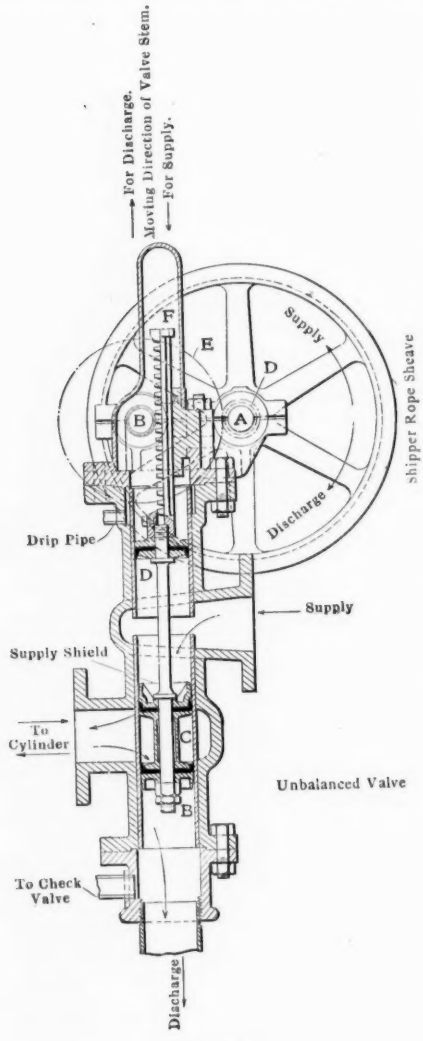


FIG. 287

unbalanced-type valve with double-geared rack and pinion is shown in Fig. 287, and a balanced valve of similar design in Fig. 288. The unbalanced valve is not, strictly speaking, unbalanced; it is only so when used in an installation where the discharge tank is located higher up than the valve. Looking at Fig. 287 it can be seen that if the pressure acting upward against the under side of piston B is the same as the pressure acting downward on piston D the valve will be perfectly balanced, because the pressure from the supply tank acts equally against the under side of D and the upper side of C. The pressure of the atmosphere acts on top of D, and if the discharge tank is on a level with the valve, the same pressure, or nearly so, will act under B; therefore, the valve will be fully balanced. If, however, the discharge tank is several feet above the valve, the pressure acting under B will be greater than that acting down on D, and the valve will not be fully balanced. The valve in Fig. 288 is fully balanced, no matter whether there is a back pressure from the discharge tank or not, because this pressure acts equally against the under side of piston B and the upper side of piston A; and the pressure of the atmosphere acts equally against the under side of A and the upper side of D. For slow-speed cars this type of valve is better than the complicated pilot valve, with its accompanying automatic stop valves, because it accomplishes all that the more complicated and expensive construction can accomplish and, being far more simple, is not as liable to get out of order. It is not desirable for fast-running elevators, however, because the movement of the car cannot be controlled with as great precision by means of the hand rope, owing to the rapid motion of the car and the long distance through which the rope has to be pulled to effect a stop. This is the only advantage of the pilot valve with car-lever control. With it a fast-running car can be stopped even with the floors of the building by anybody after a few days' practice, but with the hand-rope control only the most experienced car operators can obtain results that are at all satisfactory in large office buildings.

Lifting-cylinder Design

The casting that forms the upper end of the lifting cylinder is made in several designs by the Standard Plunger Elevator Company, one design being shown in Fig. 289, which is a vertical sectional view. The main casting is marked A; at B is the stuffing box and C is the upper end of the top-pipe section of the cylinder. The casting A is provided with a brass sleeve D that fits the lifting plunger and serves as a guide for it. This sleeve fits tightly at the upper end all the way around the circle, but at the lower end it is held in the central position by means of radial webs A' A', which are narrow enough to afford free passage for the water but at the same time firm enough to give the sleeve proper support. Their construction is more clearly shown in Fig. 290, a horizontal section through the lower end of A and D. The stuffing box B is pro-

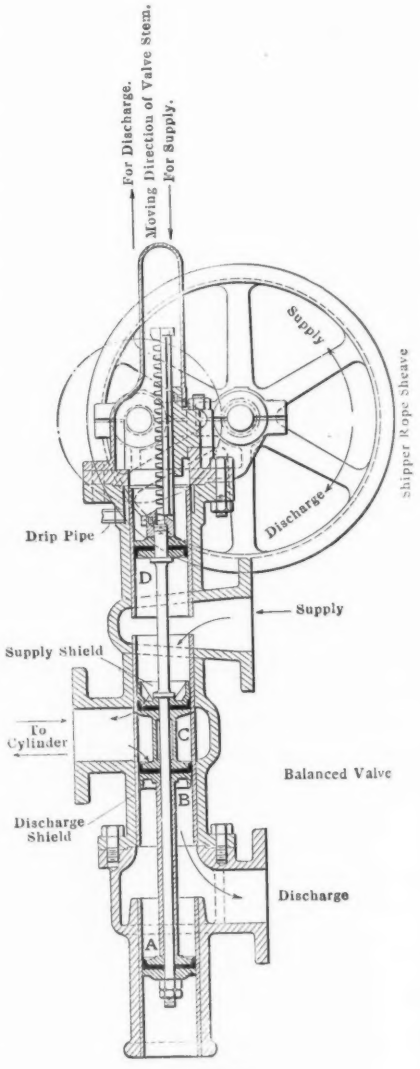


FIG. 288

vided with a gland E pressed down by studs F. The box itself is secured to A by studs F'. The packing may be of hemp, or any good, soft packing material, but usually a special design of double cup packing is used. The stuffing box is made with a rim B' which forms a basin to catch any water that may leak out of the cylinder. A drain pipe B'' is tapped in

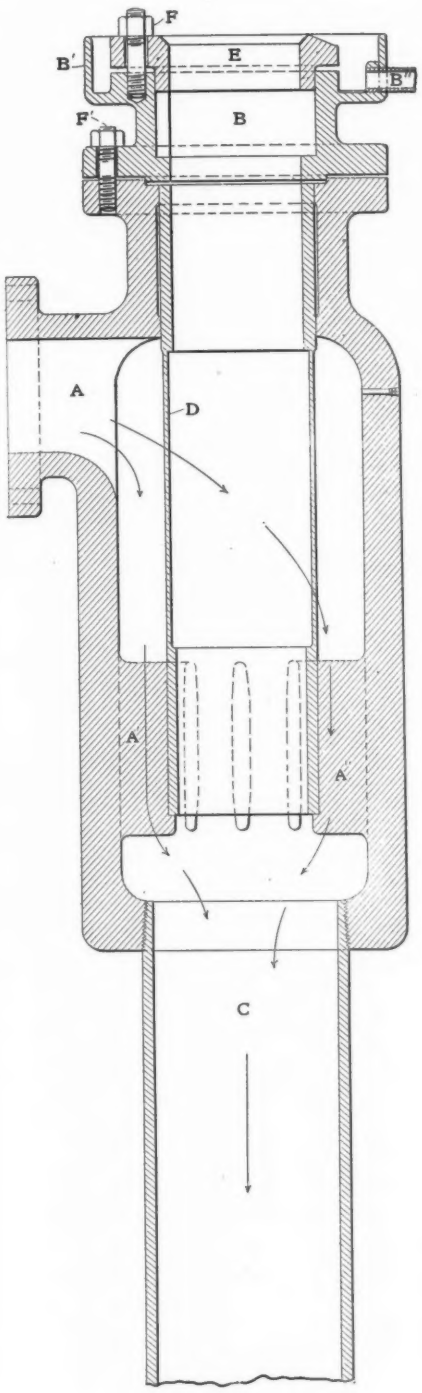


FIG. 289

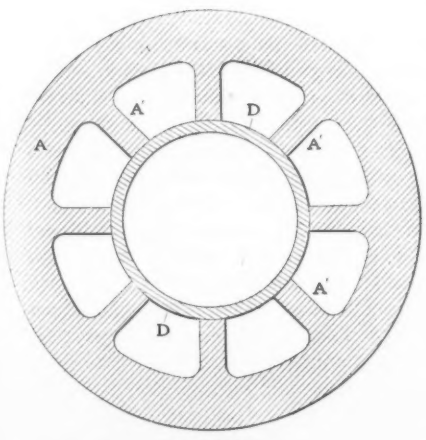


FIG. 290

on one side to remove the water as fast as it accumulates.

Fig. 291 is a vertical section of the plunger end used in connection with the cylinder top shown in Fig. 289. This end is made up of the parts *A*, *B*, *D* and *F*, which are held together by a long central bolt *G*. The upper part *A* is screwed into the lower section of the plunger *P*. The parts *B*, *D* and *F* are pressed tightly against each other by the bolt *G* and nut *C*, and all these parts are held firmly against *A* by screwing the end of *G* into *A*, as shown. The parts *A* and *D* are made of cast iron, which would rust in time, as this part of the plunger does not ordinarily run up into the sleeve *D* of the cylinder-top casting, Fig. 289. On this account these parts are incased in brass, as shown at *A'* and *E*. The construction of the upper part *A* is simple, but the part *B* is better illustrated in Figs. 292, 293 and 294, the first being a view similar to that in Fig. 291, the second a horizontal section through *L L*, Figs. 291 and 292, and the third another horizontal section on a line just above the nut *C*,

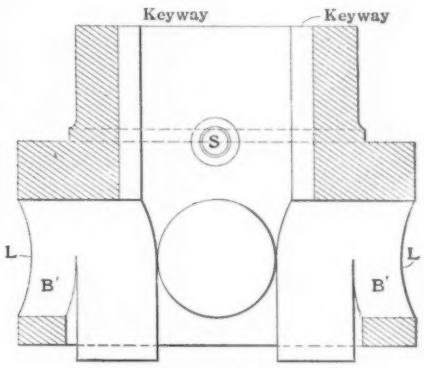


FIG. 292

Fig. 291. This piece, it will be noticed, has four holes marked *B'* that radiate from a central opening larger in diameter than the bolt *G* opposite and below these holes. Above the holes the center hole of *B* fits the bolt *G* and the latter is kept from turning in it by the two keys *K K*, Figs. 292 and 294.

The part *D* is simply a cylindrical piece shaped at its ends to fit over a projection depending from the under side of *B* and into a recess bored in the upper end of *F*, this construction being designed to bring the parts central when the bolt *G* is screwed up into the part *A*, as may be seen in Fig. 291. In this latter illustration it will be noticed that a screw *S* is run into the joint between *B* and *A* so these two parts cannot turn around with reference to each other and work the bolt *G* loose. The keys *K* prevent *G* from turning in *B*, so all these parts are securely locked; therefore, the nut *C* cannot turn, but even if it did it could do no harm because after bolt *G* is screwed up tightly in *A* the nut is not depended upon; in fact, its principal object is to hold the lower parts together when they

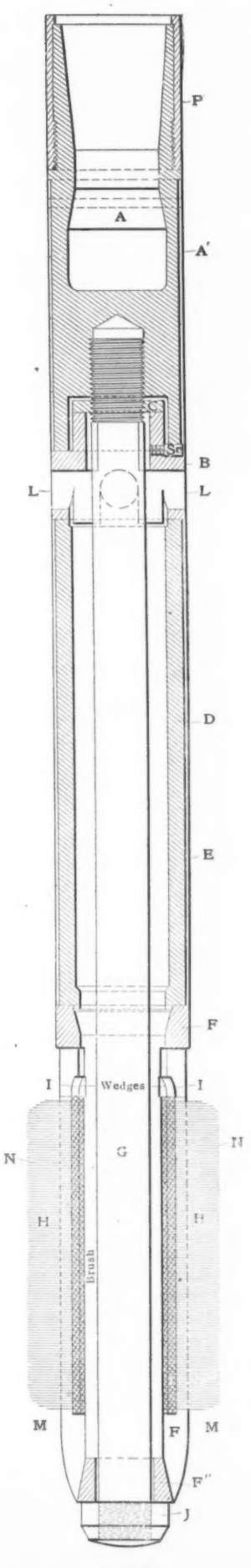


FIG. 291

are disconnected from part *A*. The lower casting *F* has a longitudinal opening through it considerably larger than the bolt *G*, and this opening has lateral connections with the exterior of the casting. As the part *D* is also hollow, there is a free passage through the end of the plunger from the bottom of the casting *F*

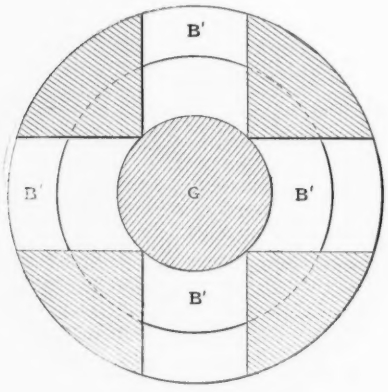


FIG. 293

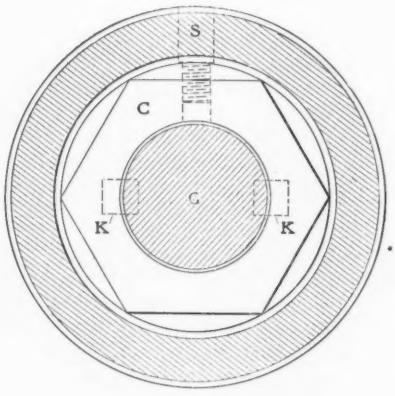


FIG. 294

to the holes *B' B'* in the part *B*. The object of this construction is to provide positive means for stopping the upward movement of the elevator car before it reaches the overhead beams, if for any reason it should fail to stop at the upper floor. When the elevator is in perfect running order, the top automatic valve will stop the car even with the upper floor and then the holes *B' B'* will be some distance below the stuffing box in Fig. 289, but if the stop valve fails to operate and the car continues upward, it will not rise far enough to strike the overhead beams before the holes *B'* will pass above the stuffing box, the water in the cylinder will find an outlet and the plunger will rise no farther.

Saturated Air as a Cooling Agent

By Arthur Pennell

Whenever it is desired to liquefy steam or other condensable vapor, some cooling agent must be employed which has the ability to absorb the heat evolved by such condensation and act as a vehicle for its disposition by some natural means. Cold water, the most obvious agent for the purpose, is often unattainable or too expensive. Air, which is omnipresent in unlimited quantity, also possesses properties which render it an efficient cooling agent.

Some Properties of Air

Absolutely dry air does not exist in the lower strata of the atmosphere. It always carries, mechanically mixed with it, more or less water vapor. Air is said to be saturated with water vapor when a cubic foot thereof consists of a cubic foot of water vapor at the elasticity due to the temperature and a cubic foot of dry air whose elasticity is the difference between the barometric pressure and the elasticity of the water vapor. The humidity of such air is 100 per cent. The two mixed form one cubic foot of saturated air at barometric pressure.

Everybody must have witnessed a white fog in a valley on a bright summer morning. The air in the fog must have been completely saturated inasmuch as minute vesicles of liquid water were visibly floating therein. As the sun rose higher and higher, the fog gradually dissipated. Sufficient heat had arrived both to vaporize the liquid vesicles and warm the air sufficiently to be able to absorb it. If, at such moment, the shade temperature was 62 degrees Fahrenheit and the barometric pressure 29.92 inches of mercury, each cubic foot of such air would have weighed 0.0761 pound and consisted of a cubic foot of water vapor at an elasticity of 0.556 inch of mercury weighing 0.000881 pound, and a cubic foot of dry air at an elasticity of 29.92 —0.556 inches of mercury, weighing 0.0747 pound. Further, each pound of dry air present would have carried 0.01179 pound of water vapor. By noon, we will assume, the shade temperature had risen to 82 degrees Fahrenheit. The air was no longer saturated but carried the same load of water vapor in a state of superheat. If such air had the opportunity of passing

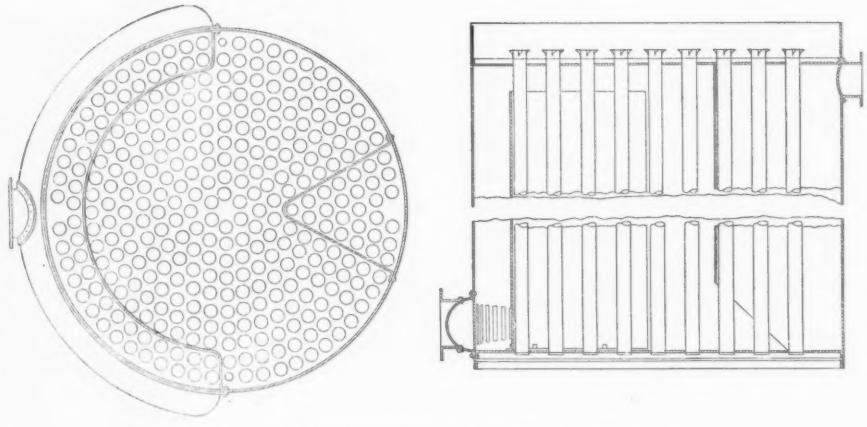


FIG. 1. SURFACE CONDENSER USING AIR AS COOLING AGENT

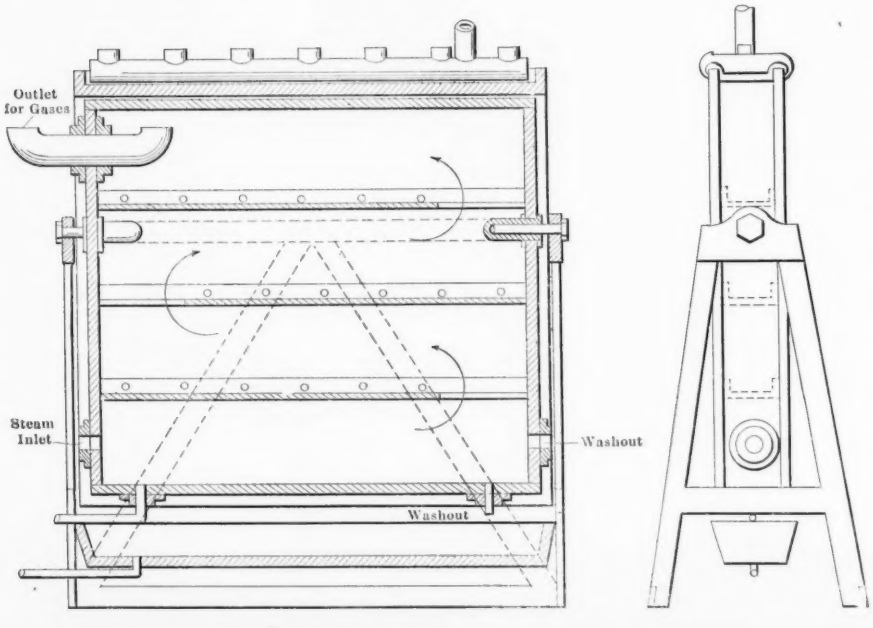


FIG. 2. SINGLE UNIT OF PENNELL FLASK-TYPE STEAM CONDENSER

over a wet, hot surface, it would absorb water vapor at the expense of the heat of the surface. Should it succeed in saturating itself with such water vapor at 82 degrees, the pound of dry air would be mixed with 0.02361 pound of water vapor and would have absorbed 0.01182 pound of water vapor from the hot, wet surface. A familiar practical example of the foregoing occurs whenever a freshly sprinkled street pavement is drying under a hot breeze.

Some Test Data

Fig. 1 shows sections of one of a pair of condensers using saturating air as a cooling agent, erected on the premises of the Armour Packing Company, of Kansas City. They were designed to condense, at atmospheric pressure, the exhaust steam from a number of simple engines developing a total of about 1100 horsepower. As one of them, while clean, was able to perform the duty, and a compound engine was being installed, the second outfit was equipped to condense the steam from the compound engine. The results of a nine-hour test follow, this condenser operating upon a York cross-compound refrigerating engine, 30x58x48 inches, running at a speed of 45 revolutions per minute:

Average steam pressure at engine, gage, lb	139.8
Average vacuum per engine, gage, in.	18.38
Average temperature in condenser, deg. F	123.7
Average temperature of circulating water, deg. F	116.4
Average temperature of city water, deg. F	52
Average temperature of outside air, deg. F	62
Average temperature of saturated air of condenser, deg. F	106
Average draft in stack of condenser, in.	0.1
Average humidity of outside air, per cent	67
Total amount of steam condensed, lb.	71,550
Average amount of steam condensed per minute, lb	132.5
Total amount of circulating water used, 16,700 cu.ft., or lb	1,032,060
Average amount used per minute, 233.17 gal., or lb	1911.22
Total amount of city water used, 499 cu.ft., or lb	31,150
Average amount used per minute 6.93 gal., or lb	57.7
Ratio of circulating water and steam condensed	1 to 14.42
Ratio of city water and steam condensed	1 to 0.435
Average horse power per hour on engine during trial, per indicator cards	569.74
Average weight of steam used, per I.H.P	13.95
Average horsepower required to run air pumps	10½
Average horsepower required to run circulating pump	3
Total amount of condensing surface, sq.ft	3900
Amount of steam condensed per sq.ft. surface, per hour, lb	2.038
Cost of city water for 9 hours, 3740 gal., at 2½ per M	9.25c
Cost of circulating condensing water for 9 hours (233.17 gal. per min.), 3 horsepower per hour, at 15c. per horsepower—24 hours, c	15.625
Total cost for 9 hours, for 569.74 horsepower, c	24.875
Cost of water for 500 indicated horsepower, for 24 hours, under existing conditions, c	58.2

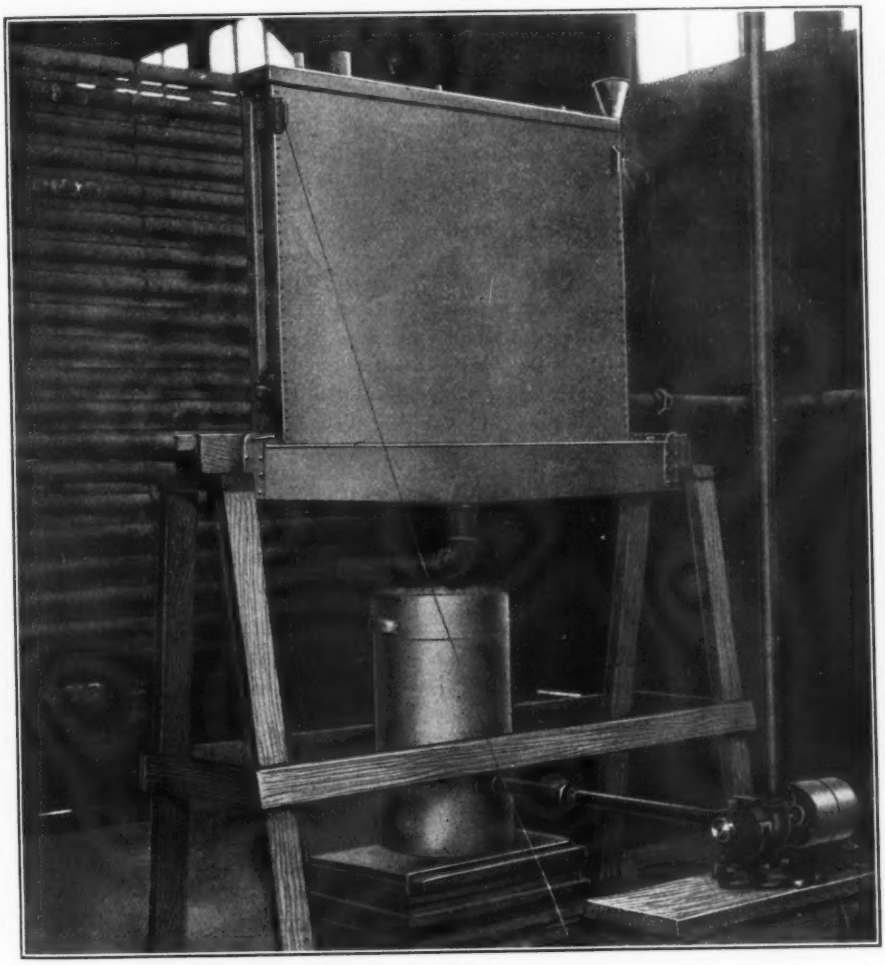


FIG. 3. AN ICE-PLANT INSTALLATION OF THE PENNELL CONDENSER

Assuming water being pumped direct from the Kaw river at a temperature of 75 degrees Fahrenheit, a lift of 40 feet, and the condenser requiring 9.373 pounds of circulating water per pound of steam condensed. Five hundred indicated horsepower (6975 pounds steam) will require 65,376 pounds of circulating water per hour; or, 1,088.75 pounds per minute; lifting 1086 pounds per minute would require 1.32 horsepower; adding 50 per cent. for friction, 1.98 horsepower, which at 15 cents per horsepower for twenty-four hours, would cost 29.7 cents.

The elasticity of vapor at this condenser temperature, 123.7 degrees Fahrenheit, is 3.827 inches of mercury, which deducted from the average barometer reading for this day, 28.58 inches, shows the ideal vacuum would be 24.753 inches; however, this ideal is impossible to obtain by mechanical means. About 21¾ inches should be obtained under best conditions.

It will be noted that the total weight of steam, condensed at a temperature of 123.7 degrees Fahrenheit, was 71,550 pounds. The condensation was effected by the atmospheric vaporization of 499 cubic feet, or 31,150 pounds, of water. The weight of water atmospherically vaporized was only 43.5 per cent. of the weight of the steam condensed. This result will be corroborated by the result of another test made elsewhere, several years later, on another type of condenser.

The amount of steam condensed per square foot of surface per hour was 2.038 pounds, when the condensing temperature was 123.7 degrees, while the initial and final temperature of the circulating water was 116.4 degrees. This figures out 287.1 B.t.u. transmitted per square foot of surface per hour for 1 degree of difference. The surface was somewhat coated with scale. The draft, due to 50 feet of flue was 0.1 inch of water. Manifestly, to obtain the low condensing temperature necessary for high vacua, artificial draft, capable of supplying three times the volume of air, would have to be installed.

A new field is now being opened for a suitable modification of this type of condenser in oil refineries, for condensing petroleum vapor. As these vapors arrive at temperatures ranging from below 100 degrees Fahrenheit to over 600 degrees, the facility of controlling the cooling agent is of considerable economic value.

Fig. 2 represents a flask type of condenser for steam at atmospheric pressure for use in ice plants. The steam enters near the bottom, follows the course indicated, condensing as it goes toward the outlet at the far end of the top bay, whence the noncondensable gases escape into the air. The condensation water is led away from an outlet in the bottom. The circulating water is caused to flow in

a thin sheet over the surface, thoroughly wetting it down, to be received in a collecting trough and thence into a catch can, from which the circulating pump returns it to the distributing system on the top.

Conditions were such that only 10-minute tests were practicable, the results of one of which is appended:

Time, Min.	Surface, Sq.Ft.	Condensed Water Entering Hot Well, Gal.	Decrease in Connecting Can, Gal.	Temp. Circulating Water, Deg. F.	Temp. Issuing Gases, Deg. F.
10	24	6	3	183	150

It will be noted that the circulating water reached a temperature of 183 degrees or 19 degrees below that of the condensing steam inside. In this case, the surface was new and absolutely clean. Calculation shows that 416.4 B.t.u. were transmitted per hour per square foot for each degree of difference. Further, the amount of water required to "make good" will be noted. The atmospheric vaporization was 50 per cent. of the amount of condensation water delivered. In this case the steam came direct from the boiler and was probably more nearly dry than in the other test. The amount of "make good" water varies with the weather conditions, probably ranging from 33 per cent. in zero weather to 66 per cent. in hot, dry summer weather.

Power Transmission in Great Britain

By W. H. Booth

A paper read some time ago by Mr. Snell before the Institution of Electrical Engineers in London appears to be the first public recognition by an electrical engineer that the electrical transmission of energy has limits to its commercial application. The fact that electrical driving of machinery can very often be shown to have effected enormous economies and often to have resulted in better work and improved output has too frequently been confounded with electrical-transmission economies. In order to transmit electricity a power plant must be laid down consisting of steam engines and boilers much in excess of the power sold, and of costly electrical generators also in excess of the power sold, for there must be a plant to make up the various losses of transformation and transmission. But the power user may himself be in as good a position to manufacture electricity as is the big supply station and the power user can adopt electric driving just as easily as if he purchased current. In Great Britain electricity has been attempted to be transmitted to users who are themselves as well placed in respect of fuel as is the power station, and whose load factor is far superior to the best load factor ever yet obtained by any power station. Power-transmission enthusiasts, encouraged by the economy of electric driving of the isolated scattered machinery of an iron-works, a shipyard or a system of docks, have imagined they could obtain equal economies in driving cotton-spinning mills, with their steady loads and load factors of 92 per cent., and they have overlooked a most important factor of the problem.

Excepting only a few of the warmer days of summer, a spinning mill requires to be constantly warmed by artificial heat. Approximately one-tenth of the heat value of all the coal burned for power appears as heat in the factory, for practically no work gets out of the factory and all the power taken by the machinery appears as heat, and, in really hot weather, provides more heat than is wanted. But every night, Sundays, and all the time for three-fourths of the year, there must be additional steam heat which the mill owner must generate in boilers, no matter how he obtains his main power. Thus, if he purchase transmitted electrical power, he must still have a couple of boilers. Even if small, he must pay a fireman, build a chimney, and must pay for main power, to a profit-making company, so much per unit as will pay that company for the coal they burn in generating electricity at a poor load factor, and for the large capital sunk in transmission lines. Now it is not possible under equal fuel conditions for any such power station to compete with a steady load of 1000 indicated horsepower produced by the user's own plant; for the cost of the user's plant is not more than the cost of the plant at the power station per 1000 horsepower, and there is no costly transmission line. The user practically saves nothing in wages, for he must have a heating plant, and he can borrow money at 4 per cent. on bonds or debentures, and that is less than the usual interest that power-transmission companies have to pay for borrowed capital.

Cotton factories in Great Britain are very usually placed along canals for the benefit of condensing water and there seems no reason why a group of mills should not obtain power from a common power station near to each member of the group; so near, in fact, that artificial heat would be supplied from the same center, thus saving every mill the expense of boilers and chimney and the wages also, for one fireman at a central station could probably supply heating steam for a dozen mills. The load factor of the central station would be better than that of any one of the factories and might be 95 per cent.

Ordinary central power stations owe their poor load factors of 25, 30 or 40 per cent. to the very bad load factors of their very few customers. The central-station man goes to the little user and says: "I can supply power for 4 cents per unit which costs you 12 cents." So the little man says he will take it and then there begins an attempt to explain the maximum demand system of charging. The little man goes away from the interview understanding that his current will cost anywhere from 4 to 16 cents, more probably the latter, but that he may hope to approach but never get down to the former figure if he will keep the small drill and the forge fan at work from 7 to 9; run two light lathes from 9 to 11, the big lathe on a light cut from 11 to 12, warm the shop and boil coffee from 12 to 1, and so on throughout the day, endeavoring to keep a steady load all day with no peak in it. The result is he does not become a customer, nor do four thousand other little would-be users of current, all of whom the central-station man insists upon fining heavily because he himself has failed to grasp the true essentials of successful business. Every electrical supplier ought to receive some training in an insurance office so that he may grasp the significance of the great laws of average.

There are four thousand little users with perhaps 20,000 horsepower of plant, and if the power station could get hold of them all they would give perhaps a load factor of 80 per cent. on a plant of 500 or 1000 horsepower and current could be sold at a flat rate of 6 cents to every little user.

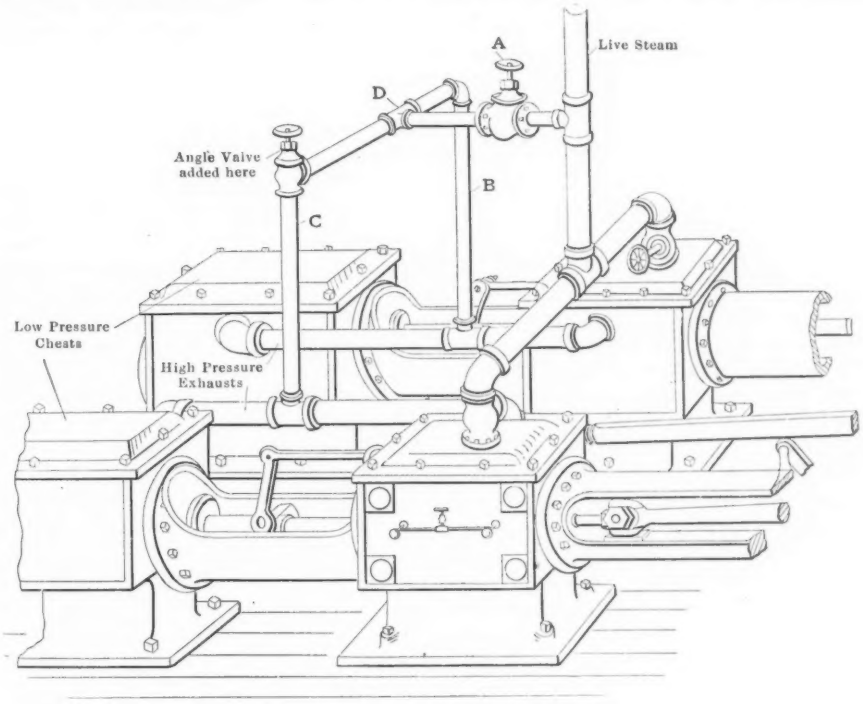
Power users differ from light users, for light users practically use light at the same moment, and numbers do not greatly reduce the abnormal peak load. This can only be dealt with by an enormous plant excess above average demand, or of a system of cheap storage such as the gas people possess. It is certain that the paltry little power stations of small municipalities cannot be expected to compete with a user's own plant when there is the added difficulty of heat supply to contend with, nor can big stations successfully supply current to large users with a high load factor. These facts, combined with the paralyzing effect of the maximum demand system of charging, and the too optimistic views of power-distribution companies, have brought the business to its present poor condition. Power stations have even been put up to sell current to coal mines and others who had their own plant and simply purchased any excess power they happened to require. Coal-burning stations have been erected to produce power in the middle of a lot of blast furnaces whose waste gases would have been equal to the supply of many times the power.

The paper of Mr. Snell much resembles a bomb in the camp, for it points out to electrical engineers facts against which they have shut their eyes and ears, and which have finally compelled recognition.

Potblyn, P. D.

By John Watson

No institution of learning had ever given him permission to write M. D., Ph. D., or anything else after his name, nevertheless the school of hard knocks, common sense and experience had surely given him the right to sign his name "Potblyn P. D." Do not suggest the addition of "Q" to the title, for the old "Doc" was not noted for the celerity of his movements, but, on the contrary, was rather slow-going and took his time to think things out before applying his prescriptions. "P. D." stands for pump doctor, and Potblyn has been applying his remedies to sick and complaining pumps for many years, and his usually successful diagnosis and treatment of a case surely entitle him to some sort of a doctor's degree.



HOW THE PUMP WAS CONNECTED UP

We have had "troublemen" working for the concern, whose idea of fixing an unsatisfactory pump was to go at it the first crack with wrench and hammer, open it up, slam around, and give a great impression of being busy and doing something. Old "Doc's" method was quite different. He might be sent to a plant where everyone, from manager to oiler, was swearing at a pump that appeared to be incapable of performing the service for which it was bought, and perhaps it was pounding and slamming and making noise enough to disturb the whole neighborhood. "Doc" would saunter in, present his card and have a cheerful "Good morning, glad to meet you" for office boy, manager, superintendent, chief engineer and everyone he met as he passed down the line. On reaching the pump room one would think that pumps were the least of all his interests. You all know the kind of cheery, old family doctor who, when he enters a sick room, starts a general conversation on the topics of the day, meanwhile studying the patient out of the corner of his eye. So "Doc" would leisurely take off his coat and start talking politics or prize fights, or anything but pumps. His eyes and ears were all wide open, taking everything in and sizing up the situation so as to have some idea of where the trouble lay before he made any move. He was a "wise old guy," for when he did get started he generally had something to go on and gave the impression that he knew just what he was about, where the trouble was located and how to fix it.

We always used to look forward to the return of "Doc" from one of his trouble trips, for he always came up in the drawing room to talk it over. Aside from the entertainment and amusement afforded by his descriptions, we always got some valuable information in regard to points which should be covered in future constructions. It was a rather poor trip when "Doc" did not "invent" something and have some new scheme to show to us. I remember one time in the early days of his employment with the company, before he had acquired the wisdom and skill which later made him such a valuable man, when we were especially anxious to hear his story.

We had a large compound-condensing direct-acting pump, working against a low head, in a far Western city. In spite of all that the running engineer could do the pistons would hit the heads at every stroke. They wrote about it a number of times and everybody from chief engineer to blueprint boy took a shot at the solution of the difficulty. We sent them a number of suggestions as to the cause and remedy, but all failed to give relief. We went over the drawings very carefully (as we thought), but could find nothing in the design that would account for the trouble. Potblyn was called into the office and asked if he had any suggestions to offer. Not a suggest.

"Can you fix it?" said the manager.

"Yes," replied "Doc."

"Then go out there and don't come back until you get it fixed."

"All right, sir."

The easy confidence of youth would tackle any job and although it involved a large expense to send a man such a distance, it seemed to be the only chance of locating the trouble. In a few days we had a letter reporting his arrival and stating the conditions as he found them, but nothing about a remedy. This was followed by daily reports detailing all of his experiments and investigations. He opened up all of the cylinders and examined the vitals, juggled the "lost motion," pumped air into the air chamber, put on a larger suction chamber, plugged the cushion release, varied the speed up and down, and tried everything that he could conceive. He took indicator cards and sent them home, asking for suggestions. They appeared to be all right and we had no further suggestions to offer.

Potblyn was "clean discouraged" and began to figure on some "hocus pocus" kind of a network of piping and valves to provide a live-steam cushion for the low-pressure pistons. At the shop we started to lay out a cutoff arrangement to be applied to the high-pressure cylinders. We had it all planned out and the drawings made, just ready to go into the shop, when a telegram came in:

"The mystery solved. Potblyn."

That was all that we heard until, several days later, "Doc" strolled into the drawing room with his hat cocked over one ear and his mouth spread east and west so far that the corners were out of sight.

"By Tokey, you're a pack of chuckle-headed idiots," was his greeting. "You fellers here get second prize for damn fools."

"What about first prize?" the chief draftsman asked.

"Oh! I've got that cinched myself, and all of the medals that go with it; you just wait until I go down in the shop and call everybody down there a fool and then I'll come back and tell you all about it."

We cornered him, however, and made him tell his story. He had to tell it in his own way and there was no use trying to pin him down to the part we were anxious to hear about until he reached it in the course of his narrative. He described all of the experiments which he had tried and

finally reached the point where he said that he was ready to give up.

"I sat down on the floor that afternoon with my back against the wall and as I smoked my after-dinner twofer I watched that cussed pump run down and bang on the end of every stroke. I wasn't much like the gay lad that came in there a week before confident that he could fix anything on earth. I was homesick. I wanted to see mama. I thought of all the gay and happy children at home, and there was I and there was that damn pump. The engineers cast pitying smiles on me as they passed. Talk about your markdowns, I felt like a left-over from a rummage sale. I was staring across the room without seeing anything in particular, when somehow my eye fixed itself on a piece of pipe leading from the high-pressure exhaust connection. Unconsciously my eyes followed it to its other connection and, say, the light that broke on me had Luna Park illumination 'skinned a mile.' I wanted to kick myself, but I thought I had better hold off until I found out whether the light was a real beacon or only another lightning bug. I couldn't do anything until the pump was shut down, but I did cheer up some, voted myself a fresh cigar and went out and threw stones at the frogs.

"Soon as they shut the pump down I went at it, broke a union, took out a section of pipe, put in a valve, and had it all done before the engineer got onto what I was doing. You bet I was on hand when he started up in the morning and, say, that darned old shebang started off and ran just as nice and quiet as a rubber-tired baby carriage when the kid's asleep.

"Not a bang, not a murmur; she's all right from then on, but as I may have remarked you're a lot of blasted idiots not to have known what was the matter, and I'm another not to have found it sooner. Some chump put in a bleeder for live steam to the low-pressure cylinders to use in starting. That's all right and worked all right, for we had to use it to start up, but the fourteen kinds of a fool connected it as shown in this drawing. [See sketch.] He put in only one valve at *A* and he connected the two branches into the high-pressure exhaust pipes, thus forming a cross exhaust from *B* to *C*. It was only a 1½-inch pipe on a 26-inch cylinder, but it was just enough to make all of the trouble and cost the company some hundreds of dollars. I put an angle valve in place of the elbow between *C* and *D* and fixed the whole trouble. Now, if the cheerful idiot that did it will come outside we will kick each other and feel better."

But, alas, "the cheerful idiot that did it" had "graduated" shortly after laying out the piping for that job. He should have known better than to make such a connection, but he slipped up on it somehow and it was such a comparatively small pipe that in checking the drawings and in erecting the pump it escaped notice. It probably would not have made any trouble but for the fact that it happened to be on a compound pump handling a large quantity of water against a low head. The momentum of the water column is liable to cause trouble under such conditions and this crossover connection, or "cross exhaust" as pump men call it, added just enough power at the end of the stroke to overcome the cushion and make the pistons strike the heads.

Do you wonder that special instructions were issued to all draftsmen to look out for all possible cross-exhaust connections however small?

Potblyn had "solved the mystery" and gained a reputation. His telegram has become a byword in the shop and whenever a pump gives trouble we suggest to Potblyn that we have another mystery for him to solve. He is very good at it and is particularly keen to spot a cross-exhaust connection, even if it is only where some engineer has failed to put the necessary valves in his cylinder-drip piping.

Some Queer Definitions

By J. E. Woodwell

Someone has said, "There is nothing new under the sun." It is certain that this person never had the pleasure and the enlightenment which comes from the perusal of civil-service examination papers. Those who have had this privilege have learned many new things, and the end is not yet. If originality is a desirable quality in electricians and engineers, Uncle Sam has an abundance of good material to select from. The writer has frequently drawn up technical examination questions, and later in reading the replies has made many startling discoveries, some of which should prove interesting to the profession.

Noah Webster was not a mechanical engineer, but we prefer his definitions to some of those given by candidates for the title. For instance, a toggle joint is variously described as: "An imperfect joint," "a bad joint," "a substantial 'soldier' joint," "a peculiar connection used in bringing two ends of the conductor together or making it as one conductor; the combination of splicing of two ends," "toggle joints are used on flexible shafts and on corner braces such as electricians use."

The definitions of an eccentric are even more eccentric than the object itself. We are of the opinion that the entire engine would be eccentric under the following conditions: "Eccentrics are used on engines, air compressors, and 'varies' other machines, and is generally connected to the piston rod." Lest any of the readers should be ignorant of the connection, we will give this man's explanation of how it is done: "A bell-crank lever is used to connect the piston rod of an engine to the eccentric." Another who described eccentric as meaning "lively; full of energy," possibly had in mind this same application.

There is evidently a difference of opinion regarding the bell-crank lever. A certain individual states that it serves to give a "Double or 'thrible' motion." Still another definition is that "A bell-crank lever is a lever shaped like a bell; a lever used to ring a bell."

In answer to the question: "Describe the construction of a self-oiling bearing on a motor or dynamo," this response was received: "Have the oil cup full of oil with a small plug in the outlet." We feel morally certain that this man does not own stock in the Standard Oil Company.

The public should not be deprived of the benefits of the information contained in the statements that:

"Armature cores are laminated to separate each layer of wires. The disks extend outwardly."

"Armature cores are laminated for their magnetic influence on the field coils. The disks extend relatively to the north and south poles."

"They are laminated in order to make the break between the positive and negative poles."

"Armature cores are laminated so as to give them more surface to 'effect' the magnetic."

The man who said that an idle pulley is "One that remains idle on the shaft" did not venture far into mechanics. Another replies, "Idle pulley: where the belt should run when the machine wants to be stopped." This machine is evidently endowed with greater intelligence than the operator.

The author of one of the descriptions of a bushing mat possesses a fine legal mind, but displays a decided lack of training. It reads thus: "A bushing is a mechanical term used to designate the part that fits into another part to separate the third part that may or may not go into the bushing; or, in other words, it is the part that separates two parts which fit into one another either tightly or closely."

The man who described a circular mil as, "A round cutter or a cutter that cuts while revolving, as a saw or milling cutter," was more of a machinist than an electrician; but the man who described it as "A table used in determining a certain value of electric current representing a part of one ohm," has not yet found his calling.

In this practical age seeing is believing, and a certain applicant in describing an ampere-turn said: "It is something I never saw on a motor." Here are other definitions of the same term:

"Ampere-turn is used to measure the voltage with."

"Ampere-turn is the turn given in its rotation around the armature."

"Ampere-turn: number of coils wound on."

"Ampere-turn is the power obtained by the resistance of a volt."

"A turn that the amperes take in a resistance coil to reduce the 'amprereage'."

"Ampere-turn is the number of turns of wire on the armature."

There is room for a difference of opinion in most of our human affairs, and there is always a chance for intelligent men to vary in their statements, but it is hard to reconcile all the following descriptions of back lash. We cannot imagine anything which would fulfil all these requirements:

"Back lash is a term applied to a strap on an engine."

"To lash and lash back."

"To throw back the table after having finished the work, making a reverse motion."

"The back lash is used in lacing a belt."

"The loose side of a belt running 'acrost' two pulleys."

A certain very cautious individual consistently avoided becoming involved in technical matters beyond his reach. He said: "Back geared means a machine constructed with gears on back instead of any other part of same."

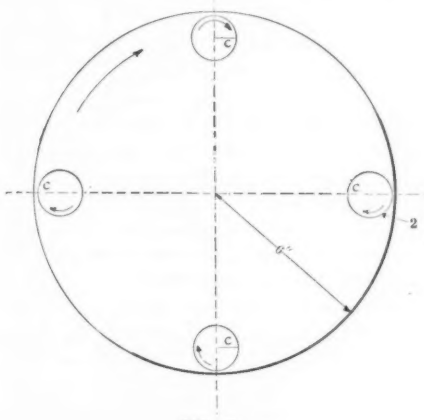


FIG. 1

One ambitious man, who drew from his imagination rather than his education or experience, made heroic attempts to answer most of the questions. To a portion of them, however, he hopelessly realized that this method of solution would not be applicable, and when he came to certain of the definitions and descriptions inserted, in lieu of an answer, the words: "Pass it up."

We believed this to be good advice, and have accordingly selected these few examples from a great number of papers and "passed them up" for the edification of all persons interested.

Pressure on the Eccentric and Crank Pin

By M. R. Carey

Fig. 1 shows four positions of a crank pin during one cycle. The approximate dimensions of the pin are 2 inches in diameter by 2½ inches long and 6.28 inches in circumference, which, multiplied by the length, will give the area:

$$6.28 \times 2.50 = 15.70$$

square inches. As the pin only touches on one side, it has a useful area of one-half of the whole, or 7.85 square inches. With a piston 7 inches in diameter and having an area of 38.48 square inches, with a constant pressure of 30 pounds per square inch, there will be a total approximate pressure of 1154.40 pounds.

Of course, there is a period in the cycle of movement when no pressure is exerted upon the crank pin. The crank rotates at a speed of 300 revolutions per minute, and the center of the pin travels 37.69 inches in the one turn, which, multiplied by 300, equals 11,307 inches. The center of the crank pin would travel 942.25 feet in one minute, while the piston speed has been 600 feet.

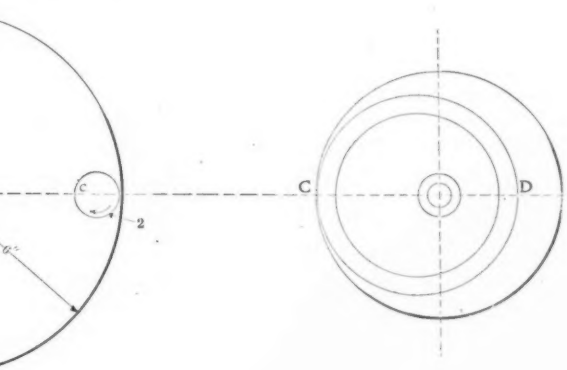


FIG. 2

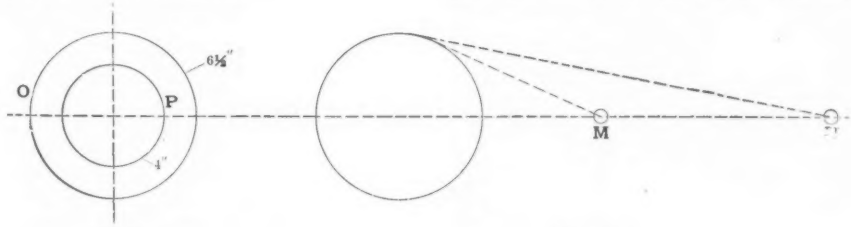


FIG. 3

FIG. 4

Referring to Fig. 1, we find a given point *C* of the crank pin, and when one-fourth of the cycle has been made we find that the point *C* has changed in reference to the point of pressure. When the pin has made one-half of the cycle this point is opposite the starting point, and at the three-fourths turn it is still farther around. The linear movement of the pin has only been 6.28 inches during one turn, while the body of the center of the pin has passed through 37.69 inches, and for one minute the linear movement of the surface of the pin has been 1884 inches when the engine is running 300 revolutions per minute, or the surface of the pin has traveled at a velocity of 157 feet, while only approximately 78 feet has been under a working pressure. This linear velocity of the pin's surface is one reason why we can lubricate a crank pin as easily as we do.

Fig. 2 shows an eccentric, the point *C* of which travels at one velocity in a circular path, while the point *D* travels at another velocity in a circular path. In Fig. 3 the extreme extension of the eccentric travels on the line *O*. Being 6½ inches in diameter, this point must necessarily travel 20.42 inches when it has made one revolution, and for one minute 61.26 inches, or 510 feet, nearly equaling the speed of the piston. This speed is much in excess of what it is supposed to be by many engineers when running small engines.

The linear and circular velocity are working under a pressure carrying the unbalanced slide valve, the load being approximately 1200 pounds. The surface usually presented by the eccentric would have a total surface of 28.27 inches, and, like the crank, only being one-half under duty, would be 14.13 inches in area. Therefore, the 1200 pounds must be carried by this surface, making the pressure and velocity per square inch considerable.

The two points on the eccentric travel at two velocities, *P* representing the lower, this being 12.57 inches in one revolution, or for the time in question 3771 inches, or 314 feet; so it is clear that the lower velocity is something more than one-half that of the piston's movement, and the true working condition might be taken as an average between the extreme movements of the eccentric. The outside or extreme point of the eccentric is constructed as working in the path shown by the outer circle in Fig. 3.

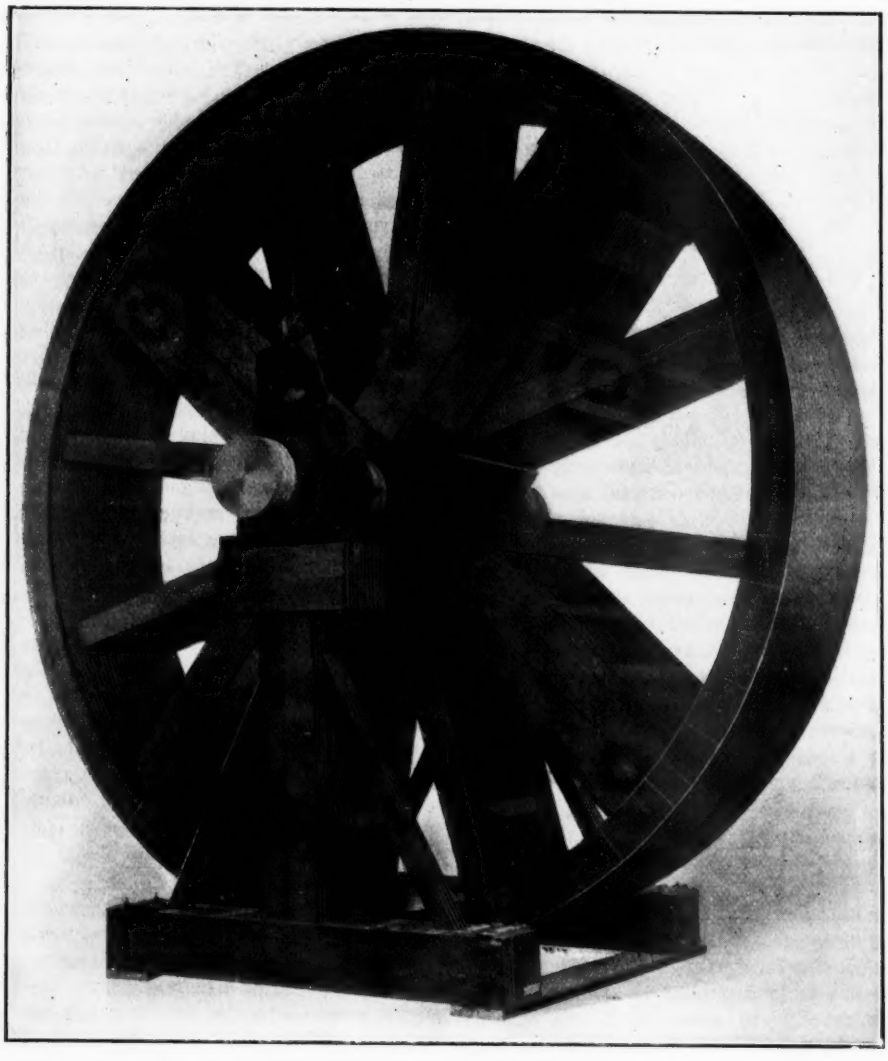
The eccentric, in many cases, works under trying conditions, and carries much more load than the man in charge gives it credit for, and at a high velocity. This is one reason why the outside crank pin for carrying the valve gear has worked so satisfactorily on the center-crank engine. Then the load becomes that of the crank relative to the movement, not in actual load, but under the same conditions. As far as velocity is concerned, it can be much lowered under this design. The one fault has been that the designer reduced his surface too much as soon as he made his crank pin a substitute for the eccentric.

The velocity of the surface of the eccentric is somewhat changed, as to the conditions under which this strain comes,

by the form of eccentric rod, and the length of the valve or eccentric rod has some effect on this. It can be clearly seen from Fig. 4 that the wearing condition of the eccentric strap having a rod as shown at *N* will be much more uniform on the eccentric than the one having a rod as shown at *M*, as the two velocities will blend better on the one having the long rod.

A Large Wood Pulley

The illustration shows a large wood split pulley which was furnished recently on a rush order by the Reeves Pulley Company, Columbus, Ind. It was 132 inches in diameter, 24 inches face, and had a $4\frac{15}{16}$-inch bore. The order was received at 9:40 a.m., and 28½ working hours later the pulley was loaded on a car and started to its destination.



PULLEY 132 INCHES IN DIAMETER MADE IN TWENTY-EIGHT AND ONE-HALF HOURS

This is the only firm, so far as we have knowledge, which builds such pulleys all wood. They have been building them for the past twelve years.

Catechism of Electricity

895. *How should the motor be shut down?*

Open the circuit breaker or main switch, allowing the machine to slow down of its own accord. Never stop a motor by releasing the lever of the starting rheostat, as this would burn the contacts on the box and might puncture the insulation of the field and armature coils.

896. *May the load now be placed on the motor?*

The motor, if new, should be allowed to run without load for a day or two so the bearings and brushes may have a chance to conform themselves to actual working conditions. When ready for the load, place the belt on the pulley and start the motor as before, closely watching the machine and everything connected with it so as to be ready to open the main switch or circuit breaker the instant there appears to be anything wrong.

When load is first thrown on a machine an ammeter should be in circuit for the purpose of ascertaining whether the machine is operating at its proper load, for if it is overloaded trouble may be experienced. The correct normal load in amperes is stamped on the nameplate mounted on the field frame.

897. *Mention any general precautions that should be observed after the load is placed on the motor.*

Inspect the motor frequently for the first few days, to guard against hot bearings, loose connections, etc. Keep all parts of the machine free from water, carbon dust and dirt of all kinds. Keep bearings properly filled with oil, and see that they do not leak or throw oil; also see that the oil does not overflow into the machine. Use every precaution to prevent oil from reaching the commutator or the armature windings. At first, the oil in the bearings should be changed once a week; later, two or three times a month.

Cleanliness is particularly essential, both inside and outside the machine. A hand bellows is convenient for blowing out dust, etc., from the inside of the machine, and an oily cloth for wiping dust, etc., from the outside. Cover the machine when not running, to protect it from dust.

898. *What troubles are most liable to arise in the operation of a direct-current motor?*

Sparking, heating, noise and abnormal speed.

899. *In which parts of the machine do the sparking and heating usually occur?*

Sparking at the commutator, heating at the commutator, brushes, armature, field magnets and bearings.

900. *What are the usual causes of sparking at the commutator?*

(1) The armature may be carrying too large a current, owing to an overload on the machine, or to friction such as that caused by the armature shaft not turning freely or the armature striking the pole pieces. A coil in the armature may be short-circuited or reversed, or there may be an open circuit in the armature. Too little resistance in the starting rheostat will cause sparking. If the armature or the pulley is not perfectly balanced, there will be vibrations of the machine which may produce sparking.

(2) The brushes may make poor contact with the commutator, they may have too high resistance, or they may not be at the neutral points.

(3) The commutator may be rough, not perfectly round, or may have some high bars in it.

(4) The field magnets may not be fully excited, or one pole may be stronger magnetically than another.

901. *How can one tell whether the sparking is caused by an overload on the armature?*

In case of a belted motor the tension side of the belt becomes very tight, and the belt sometimes squeaks owing to its slipping on the pulley. In either a belted or direct-connected motor an overload

causes overheating of the armature, and this latter may be detected without stopping the machine; simply hold the hand in the current of air caused by the rotation of the armature and note the temperature by the sense of feeling.

To determine whether the overload is friction within the machine, stop the motor, and while turning the armature slowly by hand notice if it turns hard at a certain part of each revolution. If it turns hard there is some sort of mechanical obstruction within the machine; if it does not turn hard, the trouble, if an overload, is either a too tight belt or trying to accomplish too much work with the motor capacity available.

902. *What are the symptoms caused by a short-circuited coil in the armature?*

A short-circuited armature coil becomes much warmer than the others while the machine is in operation and is very liable to be burned out. The motor draws more current than usual and if the armature be felt when the machine is first shut down, the short-circuited coil can usually be located by reason of its higher temperature.

903. *How should trouble due to a short-circuited armature coil be remedied?*

By removing the short-circuit. A piece of metal between the commutator bars or between their connections with the armature winding is usually the cause, in which case it is easily remedied. If, however, the trouble is in the coil, the defective coil will probabiy have to be replaced by a new one.

Generally, the condition of a coil will readily indicate whether repairing or a removal is necessary. When a coil in a low-voltage machine has become injured through careless handling, it may be possible to repair the damage by separating the wires properly and applying a coat of shellac or some good insulating compound. Even in motors of higher voltage it is often possible in this manner to remove a small trouble without replacing the coil.

904. *Describe how to remove an armature coil.*

If a coil is entirely burned out, it may be easily removed by cutting it in two, but this should not be done unless it is certain that no part of it can be used again. Formed coils cannot be used a second time if a part of them is cut out. When, however, an accident happens to a hand-wound coil, the good wire in it may, by taking it off, be used again.

905. *Is it not advisable to keep a supply of wire on hand in the station for replacing damaged coils?*

It is important always to have in the station the proper wire for such coils as may be wound by hand on the armature or on the field coils. A sufficient amount of it to wind at least one or two coils should be provided. When a motor is built up of formed coils, there should always be within reach several coils of the different kinds that may be needed. Besides these should also be provided the shellac, oil, tape and whatever other materials may be necessary in repairing any particular machine.

906. *Explain how to replace an armature coil.*

The manner of replacing coils depends altogether on their construction and the type of the machine in question. When a coil is to be wound on by hand, care must be taken to notice how the old coil was wound on and connected, and the new one must be put on in the same manner.

A common type of formed coils used on direct-current machines, and the manner of applying them, is illustrated in Fig. 279. Such coils when supplied for repairs are usually already bent or formed, as the two shown at *a* and *c*. When this is not the case, as with the coil shown at *d*, they must be shaped to conform with the rest of the coils. When properly bent

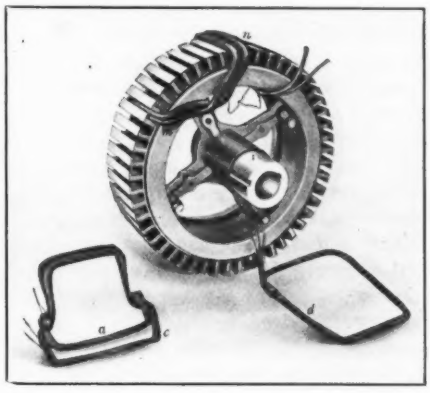


FIG. 279. FORMED COILS AND METHOD OF PLACING THEM IN POSITION ON THE ARMATURE CORE

they can be slipped in the slotted armature core as shown at *m* and *n*, their extremeties being connected to the commutator bars in the usual manner.

907. *What are the symptoms of a reversed coil in the armature?*

The motor draws more current than usual, but the coil itself is no warmer than the other coils. If current be applied in the same direction to each coil separately by way of the commutator bars and a magnetic needle be held over the excited coil, the needle when applied to the reversed coil will point in the opposite direction to that when applied to the other coils.

908. *State how trouble due to a reversed armature coil should be remedied.*

By changing the terminal connections of the reversed coil so that they correspond to those of the other coils.

909. *How is it possible to know whether sparking is caused by too little resistance in the starting rheostat?*

If there is sparking from this source it will occur only in starting up the motor. The motor will also start suddenly.

910. *What should be done to determine whether a motor has a poorly balanced armature or pulley?*

A poorly balanced armature or pulley usually causes vibrations of a stronger and more thoroughly distributed nature than those due to other causes and the vibrations increase with the speed of rotation, so that the trouble may be recognized in this way. If the indications point to the armature, the pulley, or both armature and pulley being unbalanced, they should be removed from the machine and tested separately.

The armature should be tested by placing it so that its shaft is supported at the ends upon two knife edges parallel to each other. Then, if the armature is poorly balanced, the heavy side will cause a rotation except when this side happens to be downward. By placing the armature at rest on the knife edges at different points around the shaft, the weighty side may be easily found. By providing a shaft for the pulley it also may be tested in the same way.

911. *How can a poorly balanced armature or pulley be remedied?*

Either by firmly fastening some lead on the lighter side of the core or by boring holes in, or filing off, the heavy side.

912. *If it is important that the motor be not shut down, can sparking due to vibrations of the machine be reduced temporarily?*

It can be partially overcome by giving more tension to the brushes so they press more firmly upon the commutator. This, however, is liable to develop considerable heat, both in the brushes and commutator, and should be resorted to only in cases of emergency. It may be found that the vibrations are due to an unstable base or foundation, in which case the trouble may be overcome without much difficulty.

913. *Is there not always some sparking at the commutator of direct-current motors?*

There is usually some sparking in all machines provided with commutators, but it is nevertheless a feature to be carefully watched and reduced to a minimum, inasmuch as it tends to destroy the brushes and commutator, causes trouble in the regulation of the machine and produces heat in the parts at which it occurs. A motor in perfect working condition should run without any sparking.

During the past few months the coal beds in the vicinity of Raton, New Mexico, have been investigated. The deposits here located have an area 15 miles wide, extending from Johnson's Mesa westward to the mountains. Careful investigations, carried on by the United States Geological Survey, indicate that most of the coal contained in this field is a high-grade bituminous and of coking quality.

POWER AND THE ENGINEER

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For the Good of the Order

The opportunities for self-improvement afforded by meetings of engineers are often sacrificed or minimized by lack of sufficient preparation. Instead of having a definite program arranged for each evening, a subject selected for presentation and discussion and somebody prepared to elucidate and intelligently discuss it, a chance is taken that something will come up which will make the meeting worth while. The inquiry "Has anybody anything to offer for the good of the order?" often meets with a barren response, and this part of the meeting, to which the routine business should be merely incidental, is often made a very subordinate feature. As a result the members disperse without having added anything to their stock of knowledge, without having had their interest excited, and really in a condition seriously to wonder if it is all worth while.

There are thousands of subjects any one of which will afford the material for an evening's consideration to the profit of the participants. The man who goes to a meeting and engages in the discussion and mastery of a subject which has been a mystery to him, who goes away with new ideas and an awakened interest, is likely to return and to become a valuable member and a better-informed engineer: to derive the real benefit from the association which its prospectus holds out. Many a man owes his success to the circumstance which impelled him to grasp some particular problem connected with his vocation and wrestle with it until he mastered its intricacies and made it a part of his equipment. The knowledge which the real engineer possesses has to be dug out by work and application. He cannot buy a handbook or library and sit with his feet on the desk and his pipe in his mouth and look at it and imbibe an engineering education. He cannot master principles and absorb the value of precedents by reading "easy" articles which do not make him get out his pad and pencil and think. One article which it takes a whole evening or a week of evenings to read and understand may, when mastered, be worth pages and volumes of discursive reading which has cost no effort.

The association affords an opportunity for a collective attack upon an article of this kind. Take for example the article by Mr. Jeter in our issue of January 5. This article describes a new and ingenious way of determining, by a glance at one of the charts accompanying it, whether a riveted joint in a plate of given thickness and with a given pitch of rivets will fail by tearing the plate, crushing the plate or shearing the rivets. The article while somewhat forbidding from its length and the formulas involved is very simple when one gets into it, and the instructor of any association can easily master it or refer it to somebody who can, and present it in abstract to the association, explaining knotty points and helping all the members to a thorough understanding of the subject. In order to encourage this use of the article we will be glad to loan, at no charge, lantern slides of the illustrations and charts accompanying the article to any association which desires to use them in this way.

High Boiler Efficiency

The boiler user is constantly reminded by the manufacturers of boiler compounds and tube cleaners of the inefficient results due to scaled boiler surfaces, a fixed ratio of loss to thickness of scale often being given. It has been pointed out by various authorities that such a ratio could not possibly exist, as it is a well known fact that the quality of the scale is generally of considerable more importance than its quantity. However, it is impossible to place too much stress on the necessity of keeping the inside of the heating surface clean, as not only efficiency but, what is of far more general importance, the safety of the boiler are dependent upon this condition.

When it is desired to keep the efficiency of a boiler to the highest point, the condition of the exterior portions of the heating surface is generally of more moment than the condition of the interior, particularly in the case of water-tube boilers. A thin layer of soot or ashes is a very effective nonconductor of heat and often portions of the heating surface are allowed to become banked up with soot and ashes until the effectiveness of the surface is almost totally destroyed. If similar conditions were the result of scale accumulations on the interior surfaces the metal would be at once destroyed, but in the case of external dirt no effect is produced except a rise in the temperature of the escaping gases, and hard steaming. The result is that often the cleaning of the external portions of the heating surface is neglected and the economy suffers. In many plants the periods between blowing off the external portions of the heating surface range from three days to a week. This is very much too long for economical operation where bituminous fuel is used, and in most plants once a day is hardly often enough if the highest economy is desired. The largest dividend payer in the boiler room, next to a skilled fireman, is a cleaning gang to keep the heating surfaces as nearly perfectly clean as possible. In selecting boilers the importance of this cleaning should be borne in mind, and the facilities offered by various forms of boiler or setting to accomplish proper cleaning should receive due weight in determining the kind to be selected.

Gas Power for Marine Service

The possibility of applying gas power to the propulsion of ships is becoming more and more a live question, nothwithstanding the fact that land practice has not yet attained what might be called stability. Of course the chief object in considering the internal-combustion engine for marine purposes is the saving in fuel consumption, which would reduce the cubic feet of fuel storage and thereby increase the freight space. The saving in the cost of the fuel is also a consideration, but space economy is the chief attraction. In view of the much greater space occupied by a four-stroke gas engine as compared with either a steam engine or a turbine, it would seem that the net result might not be a reduction in total plant and fuel space after all. Of course, the duration of the unbroken voyage would be a controlling factor. For a coastwise schedule, the saving in fuel space might be much less than the excess in engine space, as compared with steam.

In any event, the high value of space on a vessel of any commercial type undoubtedly points to the use of a two-stroke engine in the solution of the marine gas power problem. It is unnecessary to explain in detail the enormous space economy of the two-stroke engine over the four-stroke type; everyone who is familiar with the subject knows all the points.

Provision of adequate means for going ahead or reversing suddenly and vigorously is recognized as being another serious problem. A flywheel on a large marine engine would be an anomaly, and the only other expedient for quickly applying the full power of a gas engine to its load is the combination of three or more double-acting two-stroke cylinders, or their equivalent, with a flexible transmission, such as electrical apparatus, between the engine and the load. With electrical transmission the quick application of full power in either direction would be easy, but what would become of the precious space reduction, not to mention weight and cost of apparatus?

All theorizing aside, there is much more work to be done on both the gas engine and the producer—especially the latter—before we will be prepared to tackle "long distance" marine service.

Loops in Noncondensing Compounds

With a compound engine running noncondensing the indicator diagram from the low-pressure cylinder showed that expansion was carried below the atmospheric line, and all attempts on the part of the engineer to remove the negative loop by changing the length of the cutoff were futile.

Advice was sought from a consulting engineer, who thoughtlessly stated that the removal of the loop was a matter of easy accomplishment and who attempted to remove the loop from the diagram by the same means that the engineer had used in vain.

Failure to accomplish the desired result of course attended every effort in this direction and the consulting engineer finally advised a change of cylinder ratio by changing the diameter of the high-pressure cylinder. The change being made, an indicator diagram was taken and, as should have been expected, but much to the surprise of all interested, the negative loop was still in evidence and as large as ever.

It is not understood why any great difference in the terminal pressure in the low-pressure diagram should be expected to result from a change in the diameter of the high-pressure cylinder. To do the work a certain amount of steam was required per stroke. This amount of steam, bit off by the cutoff of the high-pressure cylinder, fell to a pressure below that of the atmosphere when expanded to the volume of the low-pressure cylinder. No change in the volume required per stroke could be made by altering the size of the high-pressure cylinder, and the only way the loop could be avoided, with the same initial pressure, was by reducing the number of times the steam was expanded, i.e., by reducing the volume of the low-pressure cylinder which each charge of steam eventually comes to fill. Indicator diagrams taken before the change of high-pressure-cylinder diameter showed that the engine was too large for the work under the conditions of operation. If the operating conditions were right, then the change to be made was a change in the size or power of the engine, and this could only be done by a change in the size of the low-pressure cylinder, for it is the low-pressure-cylinder diameter that is referred to in determining the power of a compound engine.

Valves for Superheated Steam

The American engineer visiting European power plants is usually surprised at the large number of globe valves used in the high-pressure steam lines, as well as the common absence of gate valves. This is perhaps more noticeable in the British isles than on the Continent, and is usually considered as a sign of the excessive conservatism of the European engineer. It may be well, however, to examine the conditions and the reasons given for this difference of practice.

A French engineer, who had been chief engineer of one of the transatlantic liners, says:

"We use globe valves because they can be maintained tight without the use of machinery and at little expense. The disks are always ground tight to the seat under steam pressure and the shapes of the valve body and seat are better adapted to resist the deforming action of pressure and temperature than are the through or gate valves."

A well-known marine engineer from Glasgow said:

"It is surely easier and cheaper to keep one disk and one seat tight and in line than two."

The loss from the constricted passage and the two right-angled bends in opposite directions appears negligible to them and apparently American engineers hold the same opinion regarding throttle valves, as fully ninety-nine per cent. of the throttle valves in use are of either the globe or double-poppet design.

For line work in America the gate valve is almost universally used. Formerly the only type used for high-pressure steam was the solid wedge. This type was early perfected for steam, the double wedge being used for water only. With the advent of higher steam pressures the double-wedge and double-disk parallel-seat valves became popular and threatened to drive the solid-wedge type out of use. The introduction of superheat brought a new factor into the problem, in dealing with which the solid-wedge type appears to have an advantage. It is interesting to note that there are at least two manufacturers of globe valves for use in high-pressure superheated steam lines in this country.

It is, perhaps, superfluous to prophesy as to the valve of the future. Pressures have risen to 200 and 250 pounds gage, and it seems improbable that they will be increased. Superheat at from 600 to 650 degrees Fahrenheit, the temperature at which iron appears dull red in the dark, is certainly at the upper limit, and the signs of the times point to the more moderate temperatures of 450 to 500 degrees Fahrenheit.

Floating Central Stations Propose

On December 29, William T. Donnelly spoke before the Modern Science Club, of Brooklyn, N. Y., on the use of electricity from a floating central station for the purpose of marine transportation and the propulsion of vessels. As described by Mr. Donnelly, the proposition is that in the majority of cases marine transportation of freight can be more economically accomplished in barges, lighters, canal boats and similar vessels by motor-driven propellers supplied with current from a floating central power station than by towing.

It was argued that the same amount of power distributed to several boats by means of electric cables with proper take-up drums would transport more freight a given distance than if all expended in a single towboat.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The Detroit Return Trap

An improved and modified form of the tilting return trap is illustrated herewith. It is known as the Detroit trap, and consists of a galvanized-steel tank, held in a horizontal position by a weighted arm, as shown in Fig. 1, and supported in two stuffing-box bearings located in lugs in the cast-iron base of the trap.

Both steam and water connections are situated in the base, where expansion and contraction of the pipes cannot in any way distort the adjustment of the trap and render it inoperative.

Condensed steam enters by pressure or gravity at *A*, Fig. 1, and fills the tank through the bottom connection at the left. The vent valve *B* communicates with the top of the tank inside and has a flexible connection, as shown, leading to the sewer. This valve remains open as long as the tank is in a horizontal position and serves to let out the air as the tank fills.

When enough condensation has been collected to disturb the equilibrium, the trap tilts over on the buffer spring *C*, closing the vent valve and opening the steam connection at *D*. This puts boiler pressure on top of the contents of the tank and, by means of suitable check valves in the intake pipe, allows the trap to deliver to the heater, receiver, or wherever required.

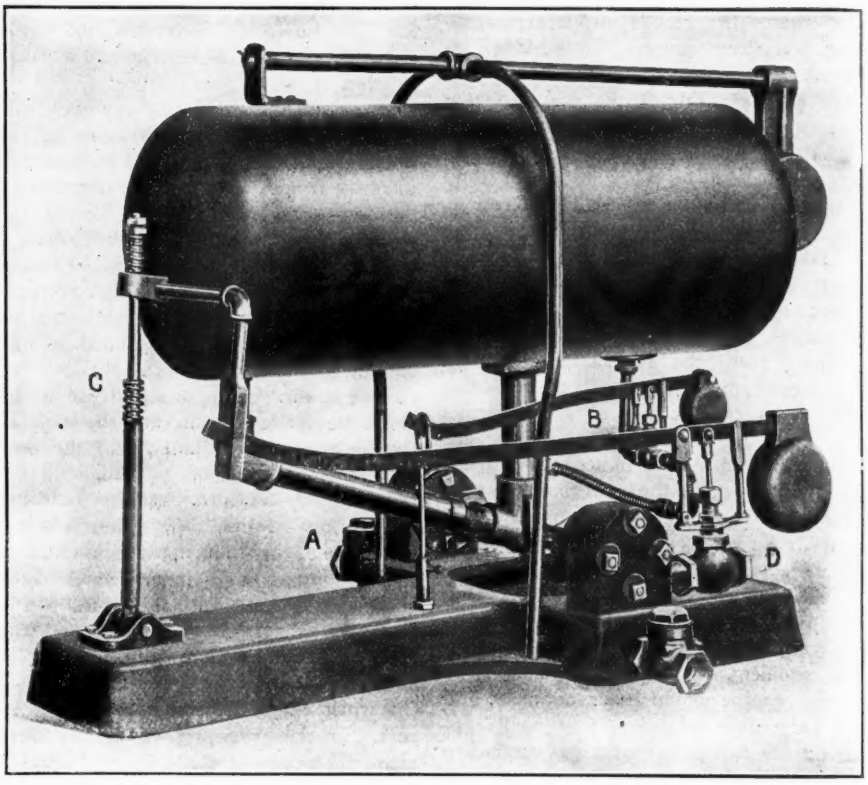


FIG. 1. THE DETROIT RETURN TRAP

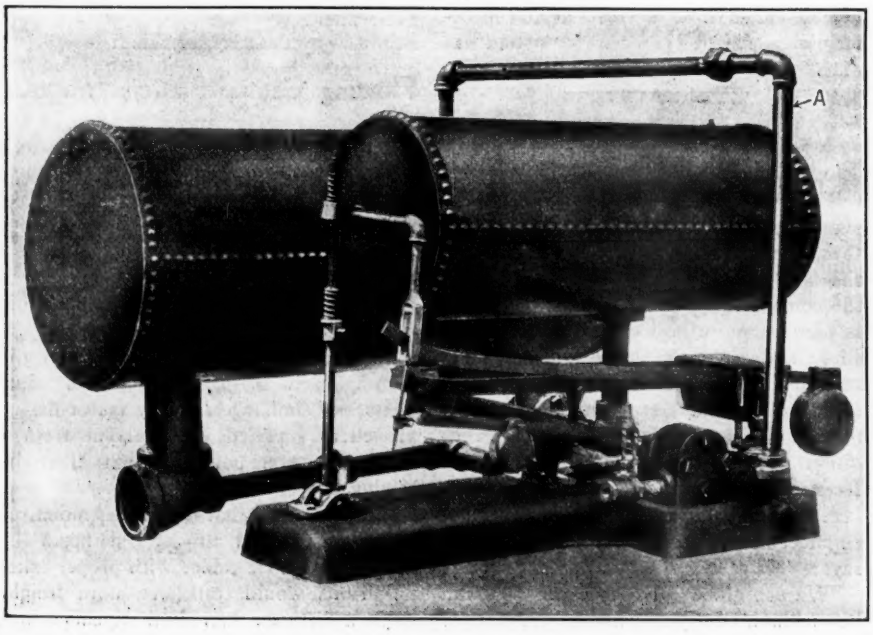


FIG. 2. SPECIAL APPLICATION OF THE DETROIT RETURN TRAP

To use as a boiler feeder, it is only necessary to place the trap at a convenient point above the water level so that, when discharging, the contents will flow to the boiler by gravity. With condensation at a very low pressure, another trap is used to deliver to the one feeding the boiler, in which case the installation is known as a double-trap system. Properly modified, these traps are successful in draining systems in which a vacuum is carried.

A special application of this trap is shown in Fig. 2. This consists of an auxiliary tank arrangement for use in places where large quantities of condensation must be taken care of.

The illustration shows an outfit designed to handle 50 gallons of condensation per minute. The trap itself has a volume of 8 gallons, and the auxiliary tank 50 gallons. A 4-inch connection leads to the large tank, the connection to the trap proper being of such size that both will

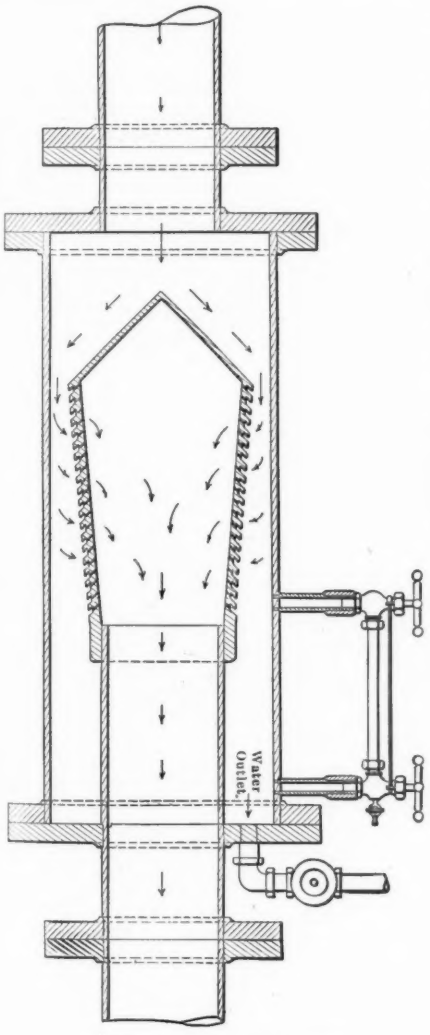
fill at the same rate. When full, the tilting of the trap turns steam at boiler pressure into both tanks, using the auxiliary connection *A* for the larger one, and the discharge in each takes place at the same time.

With this arrangement, a relatively small trap can take care of large volumes of water, it being only necessary to proportion the areas of the two water-supply pipes so the tanks will fill and empty at the same rate, the trap acting merely as a pilot valve on the system.

These traps are manufactured by the American Blower Company, Detroit, Mich.

Stanley Steam Separator

One of the advantages of this separator is the conical taper-shaped head, which is grooved or lipped so that the lips overhang each other, as shown in the illustration. This permits the water from any



STANLEY STEAM SEPARATOR

one lip to drop clear of all the others. It is claimed that once the water is separated from the steam it can never be picked up and carried over to the engine, and that the water, after being separated from the steam, does not come in contact with any metal surface that surrounds the dry steam, thus preventing condensation in the dry-steam chamber after separation.

The design is such that the large volume of steam passing through the separator is broken up into many small volumes by changing the direction of flow into an acute angle, thus permitting the water to drop freely to the bottom of the receiving chamber, whence it is immediately removed.

This separator has no baffles, funnel, pockets, troughs or vertical surface for water to lie in or cling to, and it is designed for a separator and receiver. It is manufactured by W. E. Stanley, Louisville, Ky.

"Union-Cinch" Pipe Fittings

The "Union-Cinch" pipe fittings, a type of which is shown in Fig. 1, are made in sizes corresponding to standard iron pipe up to 1-inch, and are especially designed for use in connection with oil pumps and oilers. They are manufactured by the Sight Feed Oil Pump Company, Milwaukee, Wis.

It is possible to use ordinary rough pipe with these fittings, if care is exercised in filing the ends of the pipe round and

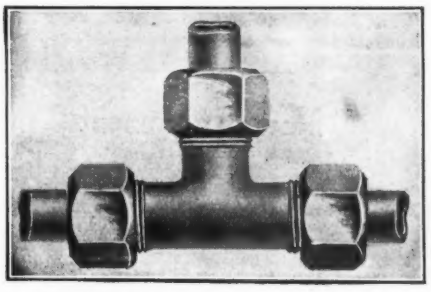


FIG. 1. "UNION-CINCH" PIPE FITTING

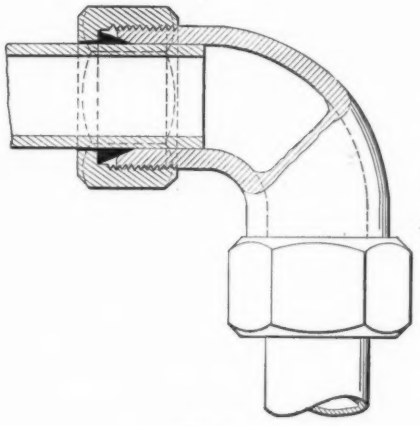


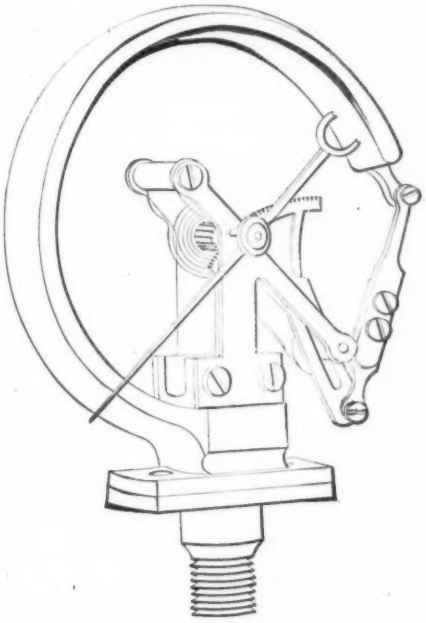
FIG. 2

smooth; but drawn-steel tubing corresponding to the iron-pipe sizes on the outside diameter is furnished by the builder. This tubing is cheap, thoroughly annealed and readily bent.

Each fitting is a union, and the piping may be taken down at any point where a fitting is inserted. The joint is made by screwing down the outside nut, which presses a thin, tapered shell into the annular cavity around the pipe, between it and the fitting, as shown in Fig. 2. These nuts may be pulled up hard and the soft cone shell will make a tight joint around the tubing, which, it is stated, is good for 1000 pounds pressure per square inch; or, in fact, is absolutely tight under any pressure that the tubing will stand. This type of joint may be taken down and made up again any number of times without trouble.

"Standard" Independent Steam Gage Movement

The accompanying illustration shows a gage movement that is distinctive in character in that a liberal air space sepa-



"STANDARD" GAGE MOVEMENT

rates the movement from the back of the case, permitting unequal thermal expansion of metal in movement and case. Considerable advantage is also gained by supporting the movement by the mounting, as twisting of the case cannot change the relative position of the working parts, which would happen if fastened to the back and the case was accidently strained out of position. Jar and vibration do not affect its accuracy or sensitiveness. The plates and segments are made of special bronze alloy; a composition selected for its perfect adaptability to conditions of wear and exposure, to which it is subject; pinions and arbors are of german silver.

This gage movement is manufactured by the Standard Gauge Manufacturing Company, Foxboro, Mass.

Presentation to an Engineer

Arthur S. Vincent, for more than twenty-one years in the employ of the *New York Tribune*, first as machinists' helper and latterly mechanical superintendent of the Tribune building, recently resigned to go with the Belnord Construction Company, of New York, as mechanical superintendent. In view of his pending change, a number of friends assembled at the Tribune building Saturday afternoon, January 2, to give him a "send-off," and at the same time to present him a silver tea service. There were present the members of the engineers' and building departments of the *Tribune* and a number of invited guests, including James P. Holland, business agent of Eccentric Firemen's local union No. 56, who made the presentation, and D. A. Mason, who will succeed Mr. Vincent. The committee in charge of the occasion, which was most felicitous, comprised John Smith, Christopher Hatfield, William Funk, "Gus" Hedin and John Healy.

Business Items

F. E. Myers & Brother, of Ashland, Ohio, are distributing their annual calendar poster for 1909.

The Ashton Valve Company, 271 Franklin street, Boston, Mass., is sending out an attractive calendar for the new year.

The Minneapolis Steel and Machinery Company will remove its Dallas (Texas) office to the Praetorian building. J. P. Greenwood is the company's representative in that section.

The Ohio Blower Company, Cleveland, Ohio, reports recent sales of eight steam separators, one oil separator, eleven cast-iron exhaust heads and twenty-one gravity-closing ventilators.

R. A. Zoeller, manufacturers' agent of Tarboro, N. C., would like to hear from manufacturers of steam specialties, with a view of handling their goods in his section of the country.

The American Steam Gauge and Valve Manufacturing Company announces that after January 1, John B. Guthrie will be its sole representative in the Pittsburg district, with offices in the Columbia Bank building, corner of Fourth avenue and Wood street, Pittsburg, Penn.

The Nelson Valve Company, of Philadelphia, recently established two branch offices in the middle West to keep pace with its rapidly expanding business, one in Detroit, in the Penobscot building, the other in Cleveland in the Perry Payne building. John M. Bulkley has been appointed sales manager for the territory of Ohio and Michigan.

D. D. Pendleton, who was connected with the Westinghouse Electric and Manufacturing Company, of Pittsburg, for some 15 years, recently opened an office as district sales manager of the American Boiler Economy Company, manufacturer of the Copes feed-water regulator, and the Copes pump governor. Mr. Pendleton's offices are located in the Frick building annex, Pittsburg, Penn.

The Commercial Testing and Engineering Company, recently opened offices and laboratories in the Old Colony building, Chicago, where it will specialize along the lines of boiler-room economies, coal analysis, heat-value method of purchasing fuel and coal washing and preparation for operators. The officers are: Edward H. Taylor, president; Harry W. Weeks, vice-president; W. D. Stuckenberg, treasurer; B. J. Maynes, secretary.

The Buffalo Steam Pump Company, of Buffalo, N. Y., has contracted with the city of Grand Rapids, Mich., to furnish ten sewage pumps having a total capacity under maximum conditions of over 250,000 gallons per minute. The pumps are to be placed in four stations, one station to contain two 18-inch pumps, one to contain two 24-inch pumps, one to contain two 24-inch pumps, and the fourth station four 40-inch pumps. The ten pumps together, without motors, will weigh approximately 200,000 pounds. Westinghouse electric motors will be used to operate them.

The Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, is in receipt of a communication from the general foreman of the El Paso-Northeastern System, Alamogerdo, N. M., in which he says: "The skimmer arrived O.K. and we at once applied it to our No. 2 boiler. We were eight hours putting it on, and that same night we began operating it. To our surprise the boiler doesn't prime over any more. Fifty gallons of lime and magnesia have been skimmed off in sixty days, and we have also experienced a decided saving in fuel. After the second week we cleaned the boiler and found at least half a wagon load of old scale, which I consider very fine. We wash our boiler only once in two weeks now, where previously we washed it twice in one week. Mr. Martin, general manager of the E. P. & N. E. railroad system, who is authority in this section on bad water and treating appliances, claims this device the best he ever saw, and has ordered three more to be put on as soon as we can conveniently get to it."

New Equipment

Dr. J. I. Coleman, Hurdle Mills, N. C., is in the market for a 100-light dynamo.

The Escondido (Cal.) Mutual Water Company will install an electric lighting and power plant to cost $30,000.

It is reported that about $10,000 will be spent in improving water-works and electric-light plant at Marlow, Okla.

The Portland (Ore.) Railway Light and Power Company has had plans prepared for a new power station.

The Waurika (Okla.) Ice and Electric Company will build a 30-ton ice plant in connection with electric-light plant.

It is said that plans are being prepared for a power station at Garden City, Kans., for the Kansas-Colorado Railroad.

The City Council, Waukegan, Ill., is said to be considering the purchase of a 5,000,000-gallon water-works pump.

The citizens of Cherokee, Okla., are said to have voted to issue $65,000 bonds for watreworks and sewerage system.

The city of Thomaston, Ga., voted $10,000 bonds for the purpose of enlarging and improving electric-light plant.

The City Council, Wooster, Ohio, is said to be considering the question of establishng a municipal electric-light plant.

The city of Thomaston, Ga., contemplates doubling the municipal electric-light plant. W. C. Hartman, superintendent.

The Union Central Light and Ice Company, Hubbard City, Texas, will make additions and improvements to cost about $10,000.

Bids will be received until 11 a.m. December 22 by Capt. O. W. Bell, Jefferson Barracks, Mo., for a complete electric-lighting system.

The question of constructing an electric light plant at Bellefonte, Penn., is said to be under consideration. W. Kelly, borough clerk.

The citizens of North Arlington, N. J., have voted to issue $25,000 bonds to install water-supply system. H. C. Bayliss, borough clerk.

The Rochester (N. Y.) Railway and Light Company is having plans prepared for a vertical retort gas plant, which will cost about $150,000.

The Waurika (Okla.) Ice and Electric Company has been incorporated. Capital, $50,000. Incorporators, T. B. Martin, E. W. Gautt and others.

The Las Cruces (N. M.) Electric Light and Ice Company has applied for franchise to construct electric-light plant and water works.

Church E. Gates & Co., Fourth avenue and 138th street, New York, have filed plans for the construction of a power house to cost about $50,000.

The City Council, Linton, Ind., will enlarge and re-equip the municipal electric-light plant. It is said about $15,000 will be spent on new equipment.

The Brattleboro & Vernon Railroad Co. has been incorporated to construct an electric railway. Incorporators, C. R. Crosby, G. L. Dunham, of Brattleboro, and others.

The city of Marlow, Okla., will make improvements to electric-light plant and water works to cost about $10,000. T. T. Eason, chairman, purchasing committee.

Bids will be received about December 20 for construction of water-works at Hays, Kan. Cost, about $18,000. Orr Engineering Company, Kansas City, Mo., engineers.

The Lake Superior Power Company, Sault Ste. Marie, Ont., is said to be making plans for a new hydroelectric plant to cost about $110,000. L. H. Davis, chief engineer.

The Booneville (Ark.) Light and Power Company has been incorporated to construct and operate electric-light and power plant and water-works system. J. T. Thayer, president.

The Freeport (Ill.) Interurban Railway Company has been incorporated to construct an interurban electric railway. Owen T. Smith, W. A. Hance and Edward Courtney, incorporators.

Plans are being made for additions and improvements to the municipal electric-light plant and water works at Macon, Mo., to cost about $18,000. E. S. Bennett, superintendent.

The Acme Hosiery Mills, Asheboro, N. C., recently incorporated with $100,000 capital, is ready to buy equipment including 40-horsepower engine and 70-horsepower boiler. O. R. Cox, secretary.

The Grand Junction (Colo.) Electric Railway Company has completed plans for construction of new electric railway, which is to cost over $2,000,000. A power plant will be constructed at Debeque.

The Vernon Light and Power Company, Vernon, Texas, will buy in the next thirty days, 150-horsepower engine, 100 kilowatt alternator, boiler feed pumps, lubricators, etc. About $5000 will be expended.

The De Kalb (Ill.) Midland Railway Company has been incorporated to construct an electric railway from DeKalb to Sandwich. Capital, $150,000. Incorporators, J. W. McQueen, W. G. Wilcox, Elgin, Ill., and others.

L. W. Trumbull, Van Vleck, Texas, is interested in an electric and refrigerating plant to supply a town of about five thousand and would like to hear from manufacturers of electrical equipment and refrigerating machinery.

Hampton Power Plant of the D., L. & W. R. R.

The Largest of Its Kind in the Anthracite Region, Employing Both Steam and Electric Apparatus of the Most Modern Type

BY WARREN O. ROGERS

A central power station at the mines, the ideal condition to which mechanical engineers have given more or less attention, is found in the Hampton power plant of the Delaware, Lackawanna & Western Railroad Company, Scranton, Penn.

In the mining of coal, three kinds of power are available: steam, compressed air and electricity. These mediums are utilized in operating all kinds of mine hoisting, pumping, ventilating, drilling and machine operation. The mining of coal is, therefore, to a large extent, a mechanical proposition, and the best means which will not only insure reliable operation but the cheapest power, all things considered, should be selected.

The central station idea has proved economical in other phases of power transmission, and recent installations of electrically driven machinery at mines have demonstrated that the central power plant at the mines is productive of economy and efficiency. In the instance of large coal-producing companies this idea is all the more feasible, because they operate numerous collieries which permit of distributing a large amount of current to them at minimum cost. Under the modern methods of wiring mines from a central station, the transmission losses which enter into the question of economies are very low. Where steam is used, the loss from condensation due to long steam pipes is considerable; the pipes in some instances being more than 3000 feet long.

Among the first to experiment with electrically operated breakers was the Lackawanna company, which has been experimenting for several years, with most favorable results. This was also one of the first of the anthracite companies to adopt the electric locomotive for mine haulage, thus doing away with steam and compressed-air locomotives.

Owing to the successful outcome of these and other electrical experiments, the Hampton power plant, the largest of its kind in the anthracite region, was installed. This station, which has a boiler capacity of more than 8500 normal horsepower, and an electrical output of 4500 kilowatts, supplies steam to five collieries and electricity to 15 additional mines. The nearest mine is only 1200 feet distant from the station; the farthest three miles away.

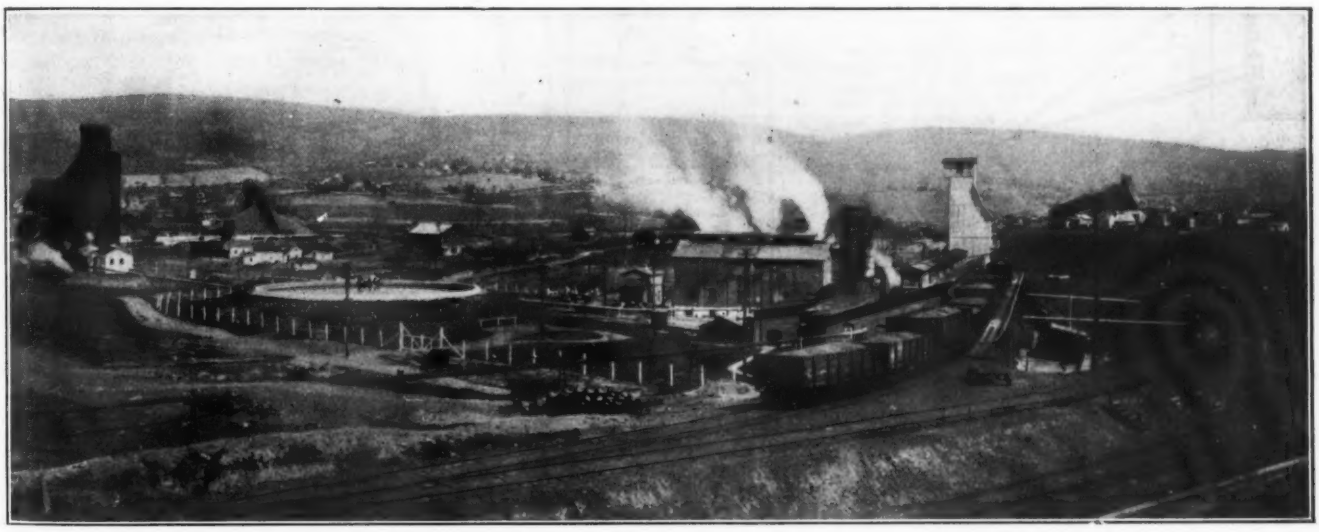


FIG. 1. GENERAL VIEW OF THE SITE OF THE HAMPTON POWER STATION

The power plant is situated in a basin formed by ranges of hills, a general view of the site being shown in Fig. 1. This location has several advantages. It is centrally located, is near its source of coal supply and obtains its boiler-feed water from the West hill section nearby. The water flows by gravity into a 750,000-gallon reservoir, shown at the left of Fig. 1, and is of excellent quality.

The buildings are constructed of brick, concrete, iron and steel. The roofs are of concrete, and no wood, with the exception of window casings and doors, is used in their construction. This feature is also observed in the construction of the oil house and work house, in which are shower baths, tubs and lockers.

Boilers

The original boiler plant consisted of fifteen 313-horsepower Babcock & Wilcox water-tube boilers, shown in Fig. 4, which are equipped with McClave stokers. A number of changes have been made in the arrangement of the furnace, however, due to the fact that barley anthracite is used as fuel. Three factors were found of paramount importance in this plant for the successful burning of barley fuel: sufficient grate area, furnace arches, necessary to maintain a high furnace temperature, and a combination of forced draft and superheated steam.

The present arrangement of the furnaces of these boilers is shown in Fig. 2. A steam conduit runs under the boilers, with branches extending to each furnace. The steam is superheated in order to reduce the moisture. Mixed air and steam enters the furnace above the grates through a number of iron pipes set in the back wall, the supply being regulated by hand from the front of the boiler. This method, when properly handled, reduces the CO from about 11 per cent. to a minimum and increases the CO_2 to about 15.2 per cent. As a result of this arrange-

ment, the fuel consumption has been reduced about 20 tons per day, with the same load.

The changes made in the stoker to meet the conditions of burning a very fine fuel, were to prevent the movement of the grate bars more than necessary to produce the proper amount of feed. The bottom end of the grate on each boiler has been equipped with a cleaning plate to facilitate dumping the ashes. The grates have an air space of 20 per cent.

Forced and induced drafts are used in all the boiler installations, the pressure in the furnace being almost balanced with a slight vacuum. The blowers were furnished by the American Blower Company and are driven by engines of suitable size built by the same company. The blower system is in duplicate, there being two 12-foot induced-draft fans, and two 10-foot forced-draft fans. The speed of the engines and fans is regulated, as the steam pressure raises or falls, by a Foster reducing valve.

The stacks are simply for the purpose

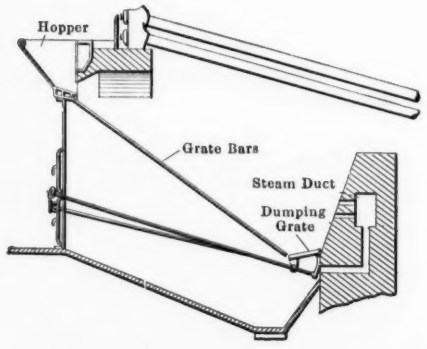


FIG. 2. ARRANGEMENT OF AIR AND STEAM DUCTS

of carrying away the gases, and are not depended on to create a draft. They are of iron, the tops being 60 feet above the surface of the grates. Two Green economizers are used with the old boilers, the gases passing through them to the induced-draft fans. The stack temperature averages 550 degrees after leaving the economizers.

The new section of the boiler room consists of six 2-drum Stirling boilers, each of 625 horsepower, the ratio of heating surface to grate area being 30 to 1. The new boilers are equipped with the Parsons system of forced draft without economizers. They are hand-fired, and the furnaces are equipped with stationary grates having an air space of 10 per cent. These furnaces are constructed with arches to assist the furnace temperature, also doors at both ends of the grates. Ash-dumping plates are also arranged to facilitate cleaning the fires.

The boilers are equipped with Murray, Williams and Vigilant boiler feedwater regulators.

As shown in Fig. 4, the coal is de-

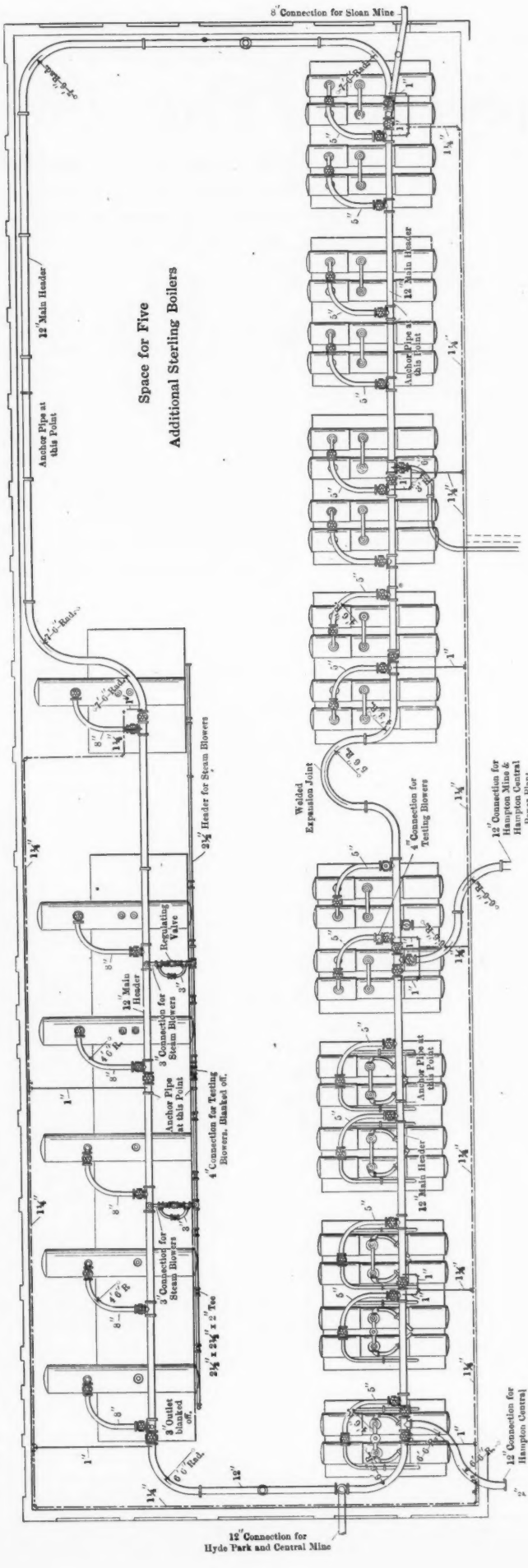

8" Connection for Sloan Mine
Space for Five
Additional Sterling Boilers
12" Main Header
Anchor Pipe at this Point
12" Main Header
Anchor Pipe at this Point
Welded Expansion Joint
4" Connection for Testing Blowers
12" Connection for Hampton Mine & Hampton Central Power Plant
3½" Header for Steam Blowers
Regulating Valve
12" Main Header
3" Connection for Steam Blowers
Anchor Pipe at this Point
4" Connection for Testing Blowers. Blanked off.
3" Connection for Steam Blowers
2½" x 2½" x 2" Tee
3" Outlet blanked off.
12" Main Header
Anchor Pipe at this Point
12" Main Header
12" Connection for Hampton Central Power Plant
12" Connection for Hyde Park and Central Mine

FIG. 3. PLAN OF THE BOILER-ROOM LAYOUT AT THE HAMPTON PLANT

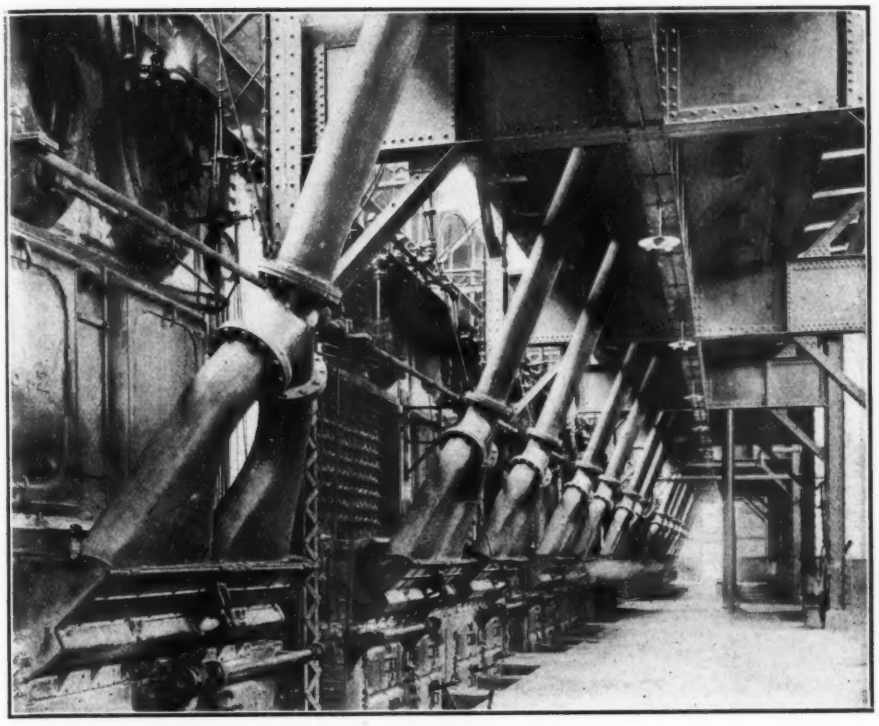


FIG. 4. VIEW IN THE BOILER ROOM

livered to the hopper in the case of the Babcock & Wilcox boilers by means of chutes from the storage bin located above and between the two rows of boilers. In the case of the new installation, the fuel is delivered on the floor in front of the boiler.

In Figs. 3 and 5 are shown a plan and elevation of the boiler-room layout. As will be seen, the Babcock & Wilcox boilers are arranged in seven batteries of two boilers and one of one boiler. The Stirling boilers are arranged in one battery of five boilers, the sixth boiler being set so that it will be the first of a second battery of six boilers, space being provided for five additional boilers, as shown. Each boiler is equipped with a superheater which superheats the steam 150 degrees. The boiler pressure carried is 150 pounds per square inch.

Piping and Valves

Each boiler is connected to a 12-inch main header of the loop construction. By this method, if one of the boilers should suffer a severe accident or a section of the header become defective, the remaining boilers and section of uninjured steam main may be operated, thus preventing the suspension of the mines depending on the station for steam and power.

The connection between each boiler and header is of 5-inch pipe, made with bends, having a radius of 4 feet 6 inches in the case of the Babcock & Wilcox boilers, and 8-inch pipes bent at the same radius in the Stirling boiler connection. The 12-inch header is bent at a radius of 6 feet 6 inches at one end of the plant and 7 feet 6 inches at the other.

From the 12-inch header the various pipe lines extend to the central power station, and to the various mines. These pipes vary in size and length, the pipes running to the turbine station being 12

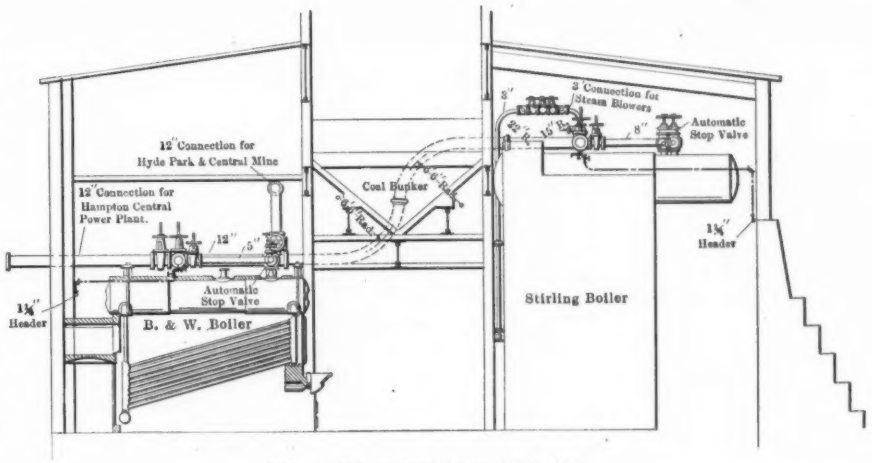


FIG. 5. ELEVATION OF BOILER ROOM

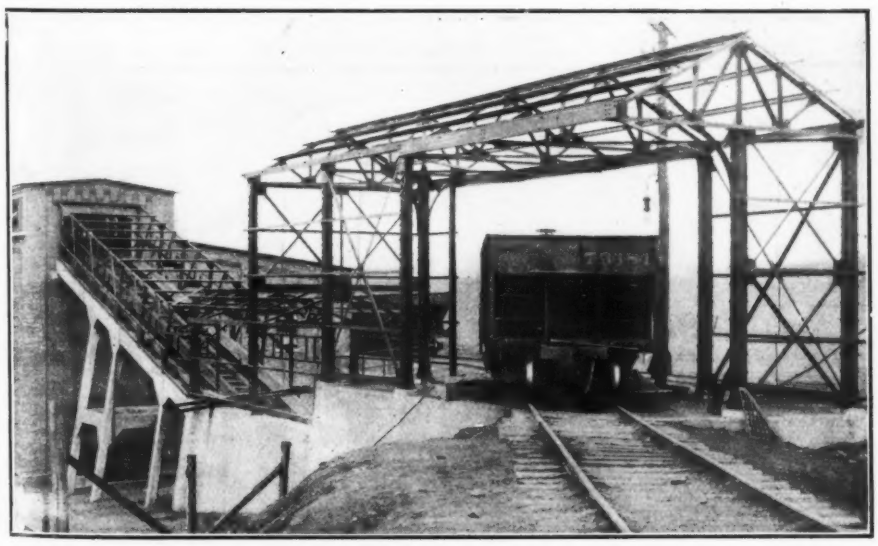


FIG. 6. SHOWING THE COAL-CONVEYER INSTALLATION

inches in diameter. The steam mains leading to the mines are as follows: One 8-inch line, 1450 feet long; one 8-inch line, 1700 feet long; one 8-inch line, 1900 feet long; one 8-inch line, 3450 feet long; one 12-inch line, 1200 feet long.

Special steel piping with flanged ends and the improved Van Stone joints is used. This joint forms an ideal method of joining high-pressure steam pipes.

The advantages of doing away with as many joints as possible on the high-pressure steam mains was the reason for the use of welded pipes where possible. This has resulted in a saving in maintenance, there being fewer joints, and a saving in first cost because there are fewer flange joints to make and cover. The advantage of welded joints is self-evident, in such instances as expansion bends or where the large high-pressure pipes make a bend of such magnitude that more than

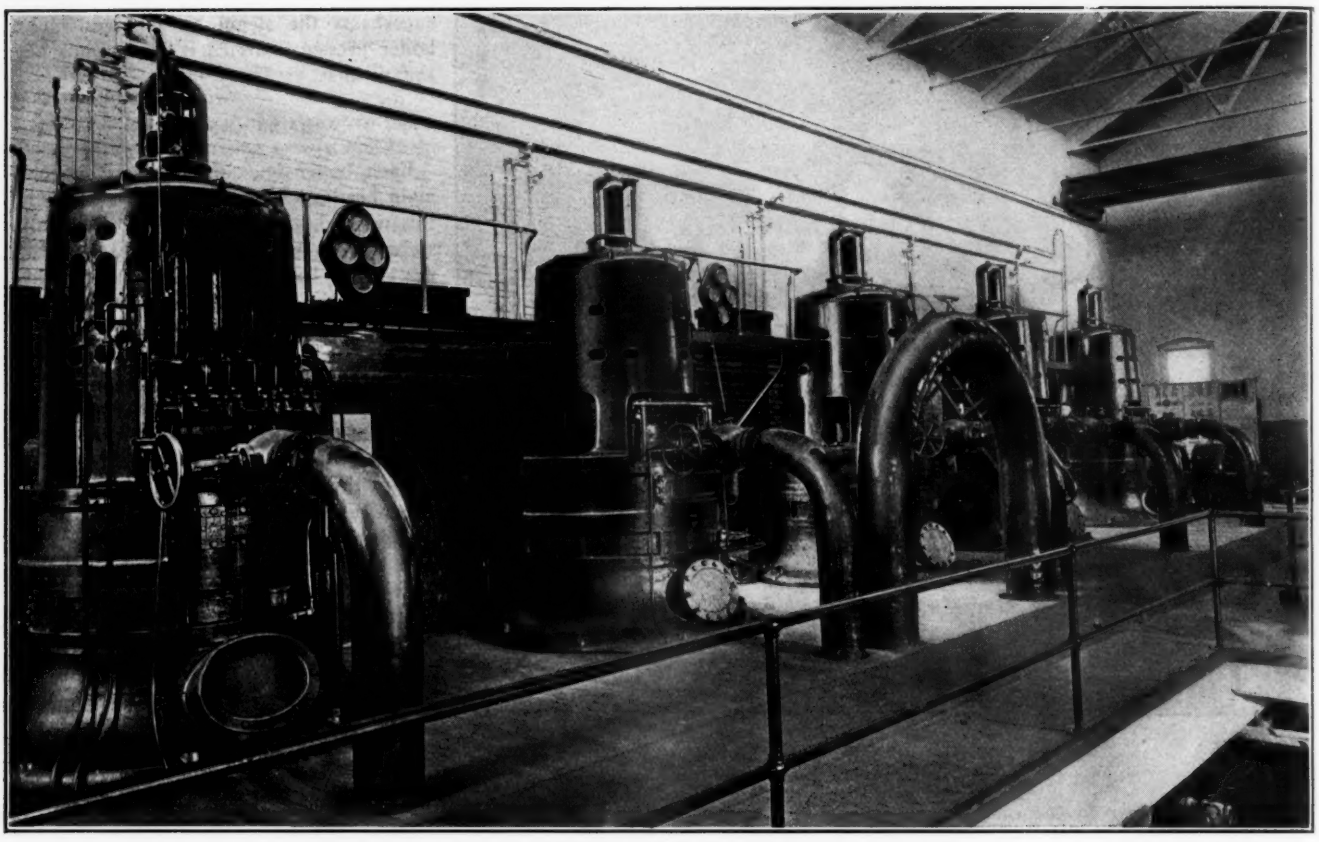


FIG. 7. VIEW IN THE TURBINE ROOM OF THE HAMPTON PLANT

one ordinary length of pipe is required. Other applications of the welded pipe are in the pipe connection between the boiler and the main steam header and the header and the prime mover. The piping system was furnished by the M. W. Kellogg Company, which also makes the improved Van Stone joint.

Another feature in the welding art is that of the welded separator placed in the 12-inch steam line leading to the turbine house. This separator is located on the outside of the building, but is protected by suitable covering, as are also the various steam pipes. It is constructed of open-hearth steel and has no joints whatever, with the exception of the inlet and outlet flanges and, in addition, even the supporting lugs at the bottom are welded to the cylinder of the separator. The body of the separator is welded together, and also to the top and bottom heads. The flanges, which are made of rolled steel, are also welded on. This separator was also furnished by the Kellogg company.

The valves throughout the plant are the product of the New Bedford Boiler and Machine Company. The globe valves are of the extra-heavy type for high-pressure service. They are designed for a working pressure of 300 pounds. The seats and disks are constructed of nickel bronze which, having the same coefficient of expansion as cast iron, makes a serviceable combination.

Disposal of Ash

A most unique method of disposing of the ash has been adopted, which not only eliminates all expense in the matter of cartage, but is turned to practical use.

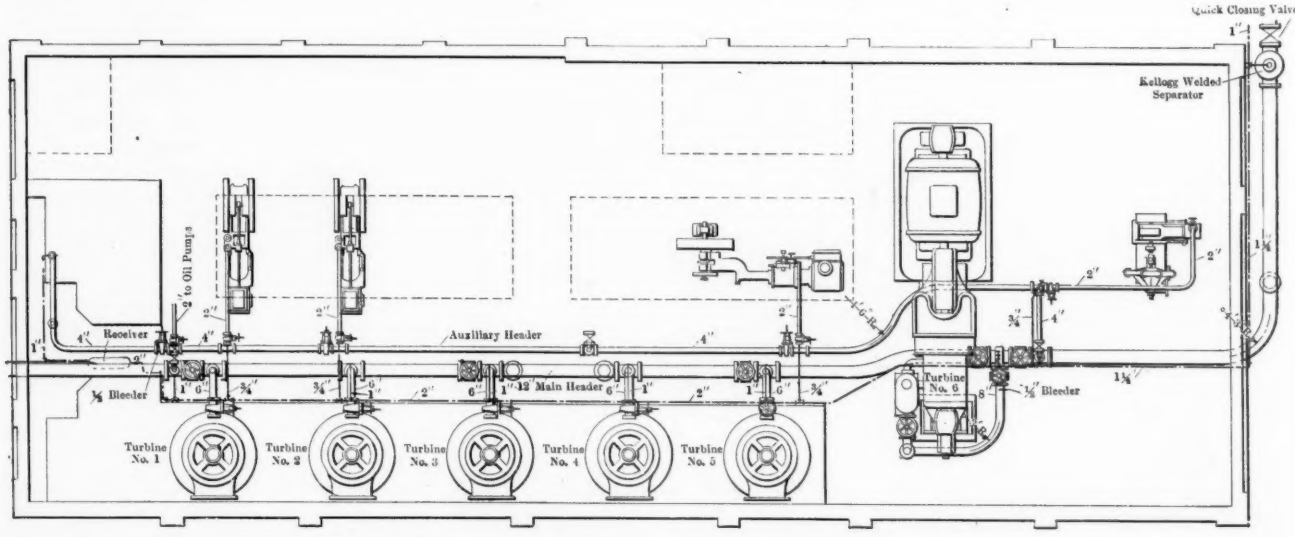


FIG. 8. SHOWING THE TURBINE LAYOUT AND DRY-VACUUM PUMPS

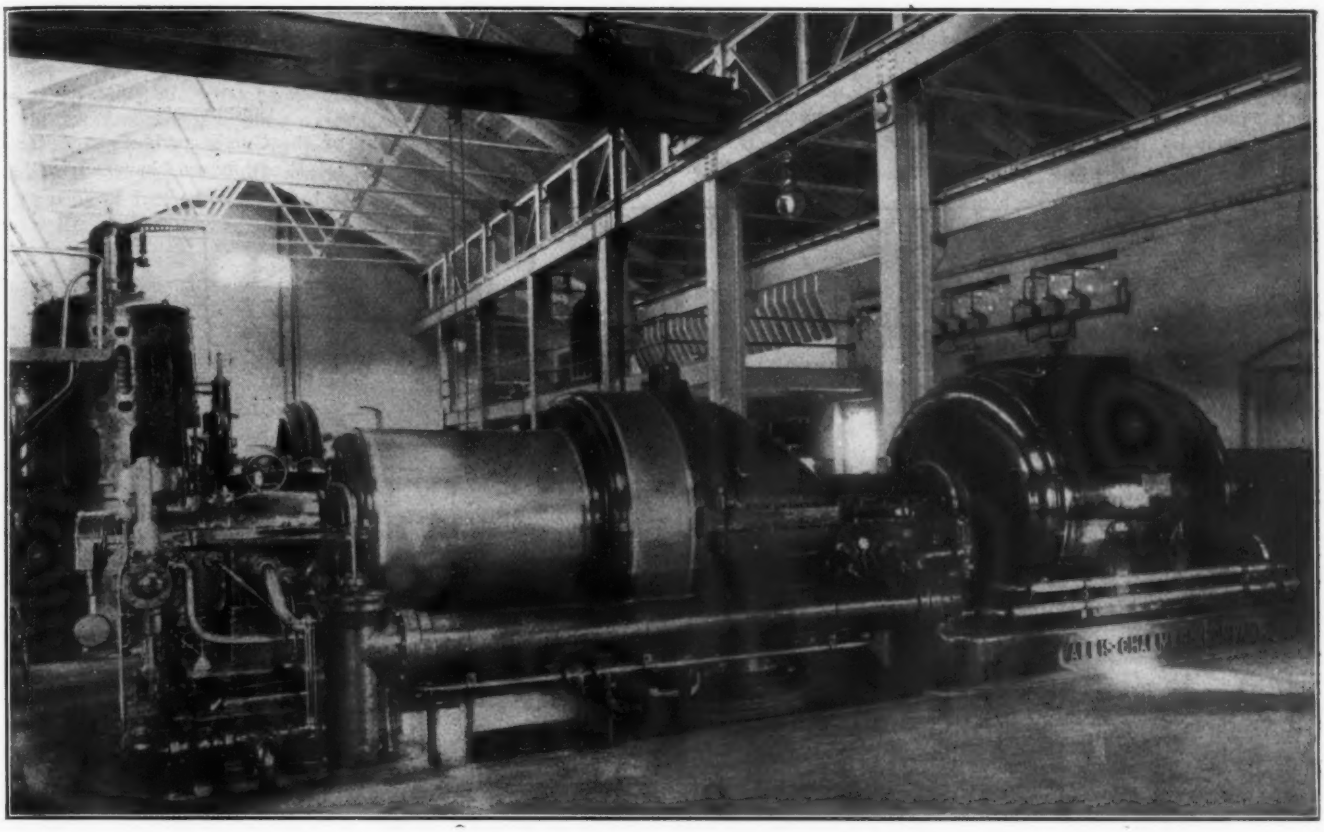


FIG. 9. ALLIS-CHALMERS TURBINE AND BULLOCK ALTERNATOR

Under the ashpits of the Babcock & Wilcox boilers a tunnel has been constructed, and beneath the furnace doors of the new boiler another set of tunnels has been built. The ashes fall from the grate in the first instance, and pass into a tunnel which has a slope of ⅜ inch to the foot. In the case of the Stirling boilers the ashes are pulled out into the conveyer lines from both the furnace and the ashpits, the latter being cleaned but once a week. Pin hole grates are used; consequently, very little ash falls through into the ashpit. Water from the mines flushes the ash into a bore hole leading to abandoned mine chambers. It is estimated that about 50 tons of ash is flushed into these chambers from under the boilers each day. As the ashes in time harden sufficiently to support the roof of the mine, the solid-coal columns, which were left in place for this purpose can be removed.

Coal Conveyer

The barley-coal supply comes from the washeries in ordinary railroad cars. From these cars it is dumped into a concrete pit having a capacity of 100 tons, from which it passes onto an endless conveyer belt and is then conveyed up an incline and along an upper floor in the boiler house, Fig. 6. Along the path of the belt is an arrangement known as the tripper, which causes the coal to be emptied into a chute, through which it is carried down into the bunkers. The tripper moves slowly along the track made for it at just the proper speed to load the bunkers, and when it gets to the end starts back again.

The conveyer belt is 750 feet long and extends the entire length of the boiler room over the coal bunker, from which the supply is delivered to the respective boilers. The coal bunker extends the entire length of the boiler room and has a capacity of 1000 tons. It is covered with concrete on which the conveyer operates. The conveyer handles an average of 50 tons an hour and is in duplicate, as shown in Fig. 6, though when the photograph was taken the second belt was not in position. It will be seen that the building over the car, the concrete coal pit and the conveyer were unfinished at the time of photographing. The incline for the rubber-belt conveyer is supported by concrete columns.

The conveyer, which was furnished by the Exeter Machine Works, is operated by a 30-horsepower Westinghouse 400-volt 415-ampere three-phase 60-cycle induction motor, running at 580 revolutions per minute.

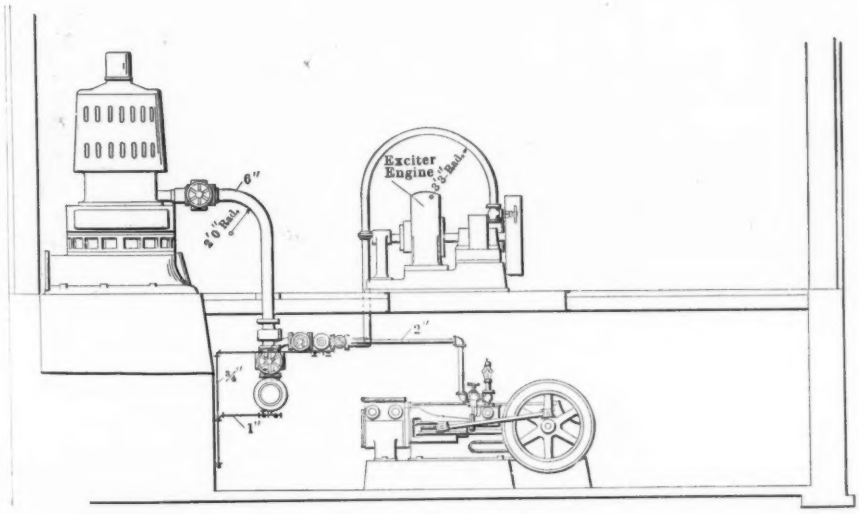


FIG. 10. ELEVATION OF CURTIS TURBINE SET, DRY-VACUUM PUMP AND EXCITER

Pumps

The pump room contains two of the Scranton Pump Company's 22 and 12 by 24-inch pumps of the outside-packed type, each equipped with a counter which acts as a check on the amount of water pumped. There is also one tandem duplex Epping-Carpenter pump, which is held as a reserve. In the pump room is also a Westinghouse air pump which compresses air for cleaning the tubes of the boilers.

The feed water for the boiler is taken from the reservoir already mentioned and is passed through a 6000-horsepower Cochrane feed-water heater.

Turbines

A section of the turbine room, which is about 25 feet from the boiler room, is shown in Fig. 7. The five Curtis turbines are located on one side of the room. They are of 500 kilowatts capacity and are direct-connected to alternators, generating a current of 2300 volts at a speed of 1800 revolutions per minute. In the right-hand corner is shown part of the air-pump pit.

The 12-inch steam header enters the basement and is tapped for a 6-inch pipe leading to each Curtis turbine. The arrangement of the piping is shown in Figs. 8 and 10, the former being a plan view of the turbine layout and dry-vacuum pumps.

In Fig. 9 is shown an Allis-Chalmers turbine direct-connected to a 2000-kilowatt Bullock three-phase 60-cycle alternator. It runs at a speed of 1800 revolutions per minute and generates a current of 2300 volts. This turbine has only been in operation a few months and represents the latest turbine design. Incidentally, it may be said that the Curtis turbine shown at the extreme end of the turbine room, Fig. 7, is one of the first, if not the first, turbines of 500 kilowatts manufactured by the General Electric Company, thus making the Delaware, Lackawanna & Western Railroad Company a pioneer in turbine practice.

In the rear portion of Fig. 9 is shown the Curtis turbine, switchboard and one of the 10-ton cranes, the other being over the Allis-Chalmers turbine and used for handling the outer bearing, if necessary.

An elevation showing the arrangement and steam pipes of one of the Curtis turbine sets, dry-vacuum pump and exciter units is shown in Fig. 10.

Condensers

Four of the Curtis turbines are connected to Worthington barometric jet condensers and one is connected to a Worthington surface condenser. The Allis-Chalmers turbine is connected to a Tomlinson barometric jet condenser. The barometric condensers are placed on the outside of the turbine building, as shown in Fig. 11.

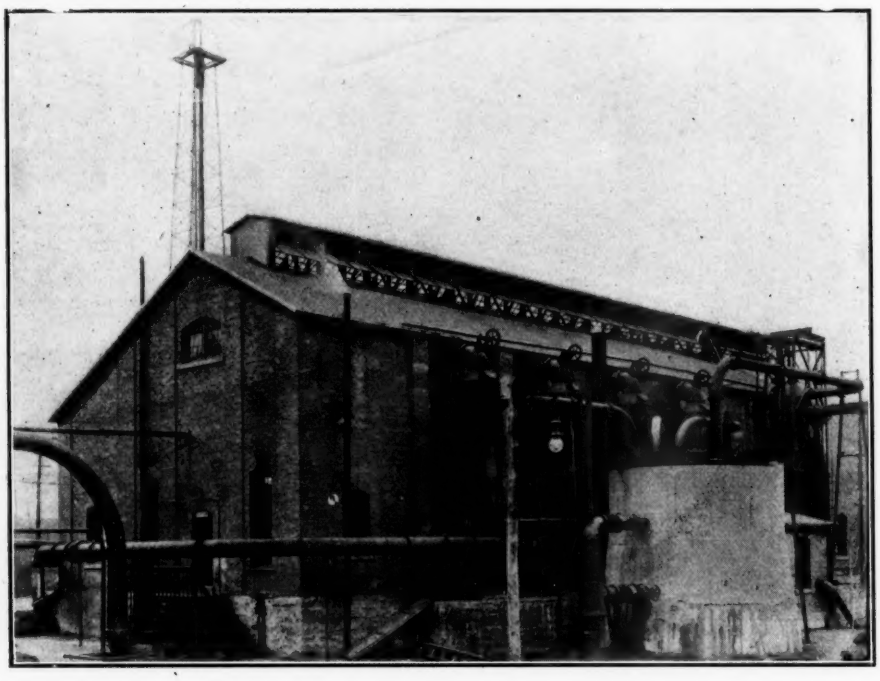


FIG. 11. SHOWING THE BAROMETRIC CONDENSERS

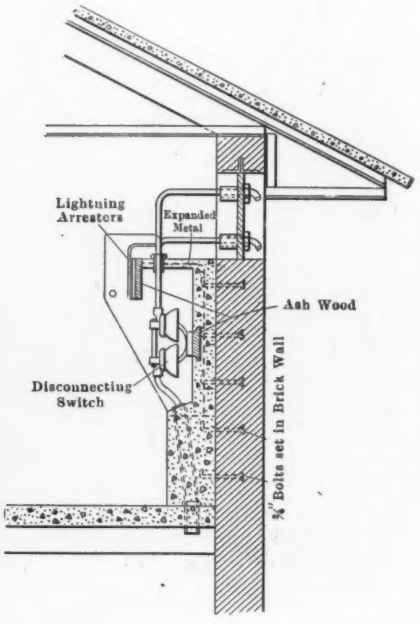


FIG. 15. ELEVATION OF LIGHTNING-ARRESTER ARRANGEMENT

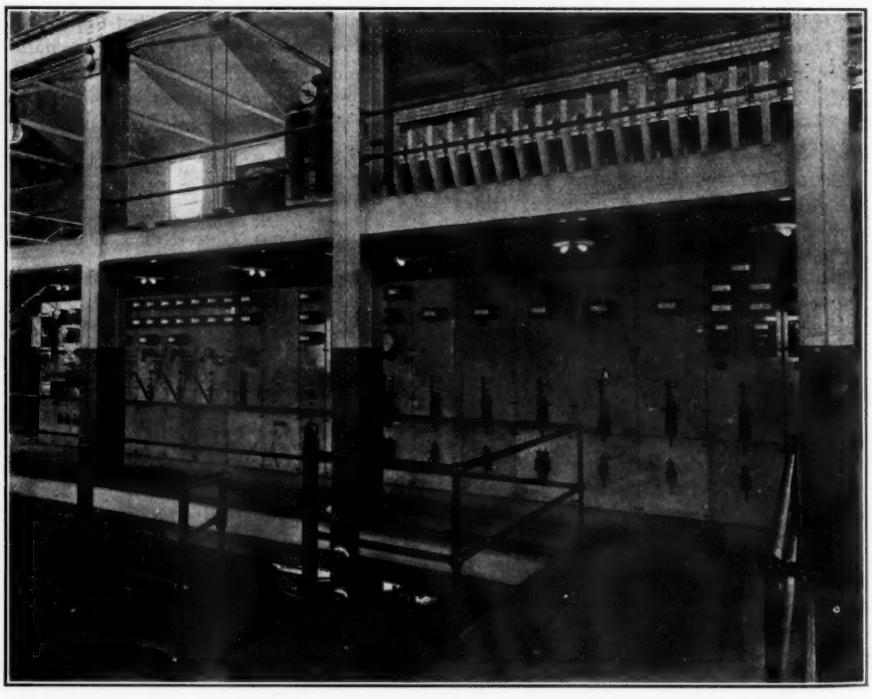


FIG. 13. GENERAL VIEW OF THE SWITCHBOARD

As is well known, mine water contains more or less sulphuric acid; therefore, considerable trouble has been encountered with the condensers, as mine water is used for condensing purposes in the jet condensers. In this case the water contains 39 grains of free sulphuric acid per gallon of water.

FIG. 12. THE EXCITER UNITS

The condenser heads were attacked as a matter of course, and to obviate this they were lined with lead as a protection. Here a difficulty was encountered, as air would get between the lining and the shell when the condensers were not in use; consequently, when a vacuum was again formed the air, due to expansion, would push the lead lining inward, reducing the area of the condenser heads and requiring more water to produce the same vacuum. Wood linings were next tried and have given fair satisfaction, and if the condensers could be operated continuously there would be but little, if any, trouble encountered. The alternate wetting and drying, however, tend to loosen the wood casing. Water-supply pipes lead to the condenser heads from the concrete tank shown in Fig. 11. The water flows to the tank by gravity through concrete pipe.

The surface condenser obtains its water from the reservoir containing the feed water. The course of the water is through the condenser to the circulating pump, and then through the heater, the surplus, if any, returning to the reservoir.

The vacuum is handled by two Worthington vacuum pumps which care for the Curtis turbines, one being a reserve. There is also a Union Steam Pump Company's vacuum pump for the new turbine. The layout of these units is shown in Fig. 8.

Exciter Sets

As in all other apparatus, the exciter units are in duplicate, as shown in Fig. 12. One set consists of a 50-kilowatt Westinghouse 125-volt 400-ampere generator, driven by a direct-connected 2300-volt three-phase 60-cycle 85-horsepower induction motor, with a speed of 690 revolutions per minute, and made by the same company. The other unit consists of a direct-current generator of the same capacity, driven by a 12x12-inch McEwen steam engine. This unit is held in reserve and used in starting up in case the entire plant should be closed down for any cause. This unit runs at 280 revolutions per minute.

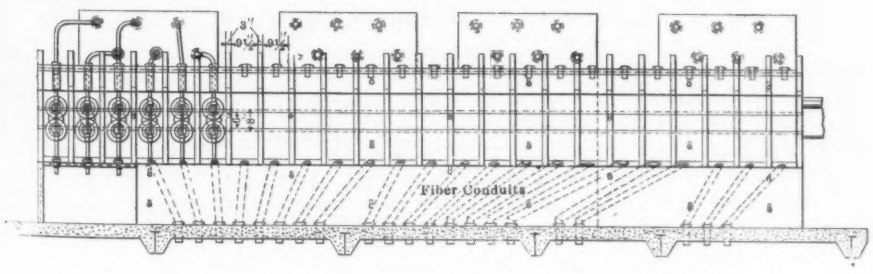


FIG. 14. PLAN OF LIGHTNING-ARRESTER LAYOUT

Switchboard

A general view of the switchboard is shown in Fig. 13. It consists of 15 panels of Vermont marble divided into six generator panels, the remainder being utilized for instrument and distributing panels, which are equipped with the necessary switches, recording instruments, etc. It is regrettable that a photograph of the rear of the switchboard could not be obtained, as it presents one of the most compact and yet systematic arrangements of switchboard wiring and feed-line distribution the writer has seen. All cables and wiring are incased in iron-pipe and fiber conduits which are arranged in an systematic manner. The feed lines, incased in the fiber conduit, pass to the lightning arresters, which are arranged in a group on a platform above and back of the switchboard, as shown in Fig. 13. A plan and elevation of the lightning-arrester arrangement and wiring are shown in Figs. 14 and 15. The arresters are attached to a concrete backing secured to the brick sidewall of the station. Between each pair of arresters is a concrete slab 3 feet 2 inches high, 3 inches thick and 14 inches wide between the arresters. These slabs, which prevent arcing in case of lightning discharge, are renewable. They are placed 9½ inches apart and are 24 in number. The main feed lines pass out through the wall, as shown.

The current generated by this plant is sent through overhead wires and lights the mines and breakers and operates the electric locomotives in the various mines. It also lights the passenger station and the railroad shops in Scranton. An arrangement is also made for switching current to the local electric company, if desired, and *vice versa*.

The writer is indebted to H. M. Warren, electrical engineer of the company, and Christopher Schillinger, engineer of the Hampton boiler plant, for data pertaining to this installation.

Effect of Superheated Steam on Mineral Cylinder Oils

According to G. W. Worrall and J. E. Southcombe, in a recent issue of the *Journal of the Society of Chemical Industry*, (1) no chemical change of a hydrocarbon cylinder oil takes place in a cylinder using steam which is not heated up to 750 degrees Fahrenheit; (2) the deposits consist chiefly of oxide of iron, which is formed independently of the oil; (3) the adhesion of the oxide-producing deposits depends upon the pitchy constituent in the oil and the completeness of distillation; (4) the oil is fractionated by the steam, the shape of the cylinder and adjacent parts, and the temperature influencing the quantity of pitchy matter remaining behind.—The London *Practical Engineer*.

A correspondent recommends the application of liquid arsenic and valve oil, in equal parts, to the hot box of a journal, to reduce the heat.

Development of the High Speed Steam Engine

Why the Compound Single Valve Engine Is Preferable Where High Efficiency Is Necessary; the Angle Compound Engine; Inertia Thrusts

Tuesday evening, December 15, Frank H. Ball lectured before the Modern Science Club, of Brooklyn, N. Y., on "The Development of the High-speed Engine." Lantern-slide illustrations were freely used. The lecture hall was filled and the discussion which followed the lecture was pertinent and interesting. What Mr. Ball said was, in part, as follows:

It has been said that Charles T. Porter is the father of this type of engine, and it is true that he built and sent to the Paris Exposition of 1875 a remarkable engine which attracted great attention because it ran at much higher speed than was customary at that time; and it ran very smoothly and quietly. The performance of this engine was partly due to the design, which made it extremely rigid, and partly to the liberal size of the bearings and the perfect workmanship.

Mr. Porter embodied in this engine a pet theory of his regarding the use of heavy reciprocating parts for the purpose of absorbing the shock of the impact of steam on the piston during admission and giving off the stored-up energy to the crank pin during the latter part of the stroke, when these parts are being brought to rest. In other words, these heavy parts were to act as a flywheel in equalizing the effort on the crank pin throughout the stroke.

Those who have seen Mr. Porter's book on the Richards indicator will remember the elaborate tables given for calculating the effort on the crank pin as modified by the inertia of the reciprocating parts. These calculations are all very correct, and are theoretically beautiful, but experience has shown that this refinement is unnecessary and that heavy reciprocating parts are very difficult to counterbalance, and are, therefore, very destructive to foundations, so that extreme lightness of these parts is now considered desirable for high speed.

The Porter engine, although it ran at a high speed, did not belong to the class since called high-speed engines, because its valve gear was entirely different, and it did not use a shaft governor.

The chief characteristics of the modern high-speed engine are the shaft governor and generally a single valve. The first engines that came into general use with these distinguishing features were built by the Armington & Sims Company, of Providence, R. I.

Then followed the familiar straight-line engine of Professor Sweet, and another that will be called to your attention soon, and as the electrical business grew, the number of builders of these engines increased greatly.

At first the electric generators were all belt-driven machines of small capacity, and the engines were therefore small. Later the generators grew in size, and as the horsepower of the engines increased to correspond, the question of efficiency became more important. The Corliss engine was then, as it is now, the standard of efficiency, but the regulation was less satisfactory than with the shaft-governor engines, and it was inconvenient and cumbersome to belt from the slow-speed engine to the high-speed generator. Therefore it became a choice of evils between the inconvenience of the slow-speed engine and the less efficient performance of the high-speed engine, with the advantage clearly on the side of the shaft-governor engines for small powers, and the Corliss engine for large powers, but with the boundary line of good practice not clearly defined. The tendency seemed to be to increase the field of the Corliss engine, and to limit the use of high-speed engines to still smaller powers, when it was found that single-valve engines were peculiarly adapted to compounding, and unlike the Corliss engine, these compound engines were very desirable for noncondensing service.

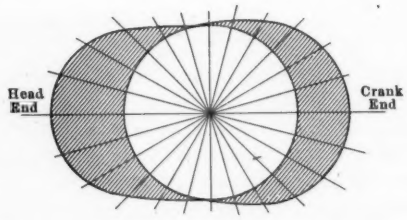


FIG. I. 160-HORSEPOWER SIMPLE ENGINE. UNBALANCED RADIAL FORCES WITH RECIPROCATING PARTS COUNTERBALANCED

This changed the situation materially, for it was found that the high-speed compound engine was appreciably more efficient than the simple Corliss engine, so that the boundary line of good practice was moved up a long way into the field of larger powers, which had been held by the Corliss engine.

These compound engines first appeared as tandem engines, or as cross-compounds, but always with a shaft governor, and for many years the single valve was universally used. During all these years there was great similarity between the engines produced by the large number of builders of this class of machinery, but presently there began to be a divergence in the ideas of designers. Some sought to improve the efficiency of the single-valve engines by the use of complicated valve gears and an increased number of valves, while others claimed that the small gain in efficiency to be obtained by a multiplication of the valves and parts is more than offset by the increased cost of maintenance, and the greater liability of interrupted service, and that where high efficiency is desired a better plan is to use a compound engine of simple design and few parts.

The advocates of the multiple-valve high-speed engine answered this argument by proposing to compound the four-valve engine, while the opponents of the plan condemned it severely as being a wholly impracticable arrangement, because of the greatly increased number of parts and the rather appalling complication, which was held to be very objectionable for high speed.

Those who advocated the simpler valve gear for high-speed engines sought to realize the extreme of simplicity and fewness of parts. An illustration of the development in this line is found in the type known as duplex-compound. Comparing this with the compound engine just considered the difference in the valve gear is rather startling to the man who is expected to maintain these mechanisms.

Bear in mind that both these engines are compound engines. The engine wtih complicated valve gear gives slightly better efficiency, but the saving is unimportant. The following table of the number of parts in the valve gear of both engines makes an interesting showing:

	Eight-valve Compound.	Duplex Compound.
Number of eccentrics	2	0
Number of eccentric crank-pins	0	1
Number of eccentric rods	2	1
Number of connecting links	12	0
Number of rock arms	19	2
Number of rock-arm pins	26	2
Number of valves	8	1
Number of valve stems	8	1
Number of stuffing boxes	8	1
	85	9
Total number of working bearings	42	5
Total	127	14

The question naturally arises, what is the increased efficiency to be obtained by all this complication? The relative performance of the three classes of engine,

the Corliss, the four-valve high-speed engine and the single-valve engine, may be best illustrated by comparing simple engines of these types. The Corliss engine has been so long known and so fully tested that its performance is well established as approximately 26 pounds of steam per horsepower per hour under usual conditions. The single-valve engine has been very definitely located at about 30 pounds per horsepower per hour, but the four-valve high-speed engine is newer and its efficiency is not so well known. Without regard to what may be finally considered a fair representation of the average performance of this engine, it must be evident that because it does not use the releasing valve gear, and because its clearance is necessarily greater than the Corliss engine, its efficiency must fall short of the standard efficiency of the releasing-gear engine, and its performance must therefore be between the Corliss and the single-valve types.

It has been abundantly demonstrated that the single-valve compound engine develops power on a consumption of from 22 to 24 pounds of water per horsepower per hour and therefore it is a more efficient engine than any type of simple engine.

It becomes, then, a question of the practicability of compounding the four-valve high-speed engine. Here again an interesting comparison may be made between the two types of valve gear, as follows:

NUMBER OF MOVING PARTS AND WORKING BEARINGS IN VALVE GEAR.

	Simple Engine.	Compound Engine.
Four-valve type	71	127
Single-valve type	14	14

From this table it appears that the single-valve engine may be compounded without increasing the number of parts of the valve gear, whereas the compounding of the four-valve engine increases the number of these parts 60 per cent.

The matter is summed up by the advocates of simplicity in high-speed engines as follows: Where the efficiency is not important the simple single-valve engine is desirable because it represents the smallest initial investment and the least cost of maintenance.

If high efficiency is necessary, then the compound single-valve engine is better than the simple four-valve engine, because it does not increase the number of parts of the valve gear and it is appreciably more efficient than any form of simple engine.

Leaving these comparisons and going back to the early days of the high-speed engine, you will remember the pioneer engine with shaft governor, known as the Armington & Sims engine. Then followed the straight-line engine of Professor Sweet and about the same time the engine which is to be followed in its development through all these intervening years.

The distinctive features of the high-speed engine are the shaft governor and the single valve, but we will not undertake to follow the development of these governors. A description of one of the latest designs may be interesting. The features of this construction are the gravity balance and the arrangement of the springs. During the whole period of the development of the engine the same form of the valve has been used continuously in the simple engine.

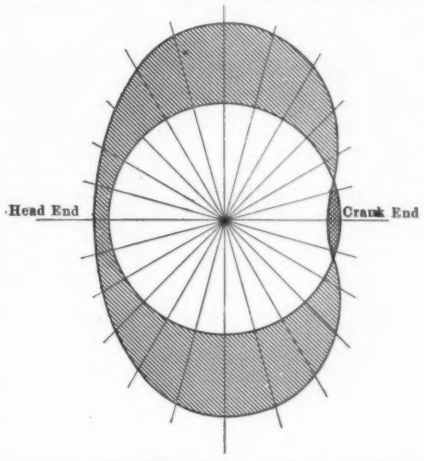


FIG. 2. 160-HORSEPOWER SIMPLE ENGINE. UNBALANCED RADIAL FORCES WITH RECIPROCATING PARTS COUNTERBALANCED

Going on now to the compound engines as the next stage of development, the duplex-compound will be investigated as being along the line of extreme simplicity. The latest development along the line followed is a new type of compound engine that many of you have not seen.

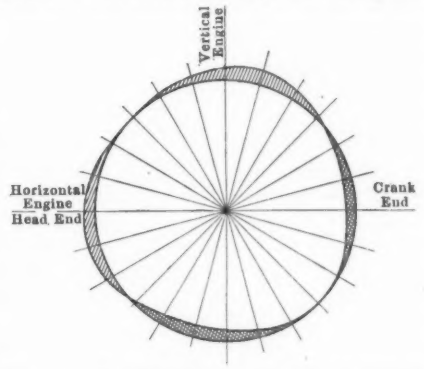


FIG. 3. 160-HORSEPOWER ANGLE-COMPOUND ENGINE. UNBALANCED RADIAL FORCES WITH RECIPROCATING PARTS COUNTERBALANCED

This engine is called the "angle-compound" because the high-pressure and low-pressure elements are placed at an angle of 90 degrees in the plane of the crank's rotation, and both connecting rods engage the same crank pin, being placed side by side on a pin of double the usual length. This general arrangement is not new. It is the general plan of the mammoth engines installed in one of the large traction power houses in New York City, and has been very successful there and elsewhere.

Engineers do not seem to have realized, however, the peculiar advantages of this form of construction for small high-speed engines, where the counterbalance problem makes smooth running and freedom from vibration increasingly difficult as the speed is increased.

With even moderately high speed it has been found wholly impracticable to depend on ordinary foundations to resist the unbalanced inertia thrust of the reciprocating parts of horizontal engines, so a certain amount of counterbalance is therefore placed opposite the crank to neutralize these inertia thrusts.

The difficulty here encountered is that, while it neutralizes horizontal thrusts, it also develops an unbalanced thrust in a vertical plane, so that, contrary to a very prevalent idea, the reciprocating parts of an engine cannot be counterbalanced by a rotating counterweight, and it becomes a matter of choice as to what part of this thrust shall be transferred from the plane of the engine to a plane at right angles to it. With horizontal engines it is common practice to use a counterweight to the extent of transferring the larger part of the inertia thrust to a vertical plane, because ordinary foundations resist vertical thrusts more successfully than horizontal thrusts. The magnitude of these thrusts increases as the square of the speed of rotation, so that at very high speeds they become very serious.

It has been positively demonstrated that the counterbalance in the driving wheel of a locomotive, necessary to prevent the engine from "nosing" badly at high speed, develops so much vertical thrust that the wheels, with the weight of the locomotive on them, actually lift clear of the rail at each revolution.

Keeping this all in mind it is evident that with the angle-compound engine the counterweight necessary fully to neutralize the inertia thrusts of the horizontal engine is just what is required to neutralize the inertia thrusts of the vertical reciprocating parts when the crank passes the line of centers. A practically perfect balance may therefore be obtained if both sets of reciprocating parts are made to weigh the same, and the counterbalance be made sufficient entirely to neutralize the inertia thrusts as the crank passes each of the four centers.

This is just what has been done in the angle-compound engine, with the result that remarkable smoothness of running is obtained even at very high speeds and the foundation problem becomes a very simple one. There are four small impulses on the crank pin of this engine at each revolution, instead of the two large ones ordinarily delivered to the crank pin of an engine. This is a very favorable

condition for uniform rate of rotation without heavy flywheels and, because the shocks of impact are small on all these bearings, the wear is proportionately slight and the tendency to heat is reduced.

Among the many views shown on the screen were three showing the inertia thrusts of the reciprocating parts on the crank pin. These were graphic illustrations of the extent and direction of the force developed. Fig. 1 shows the direction and extent of the inertia force in an engine with unbalanced reciprocating parts; Fig. 2 shows the transference of force from the horizontal to the vertical plane when the reciprocating parts of the engine are as nearly balanced as may be by revolving weights; and in Fig. 3 is shown the inertia stress exerted in the angle-compound engine with the weight of both sets of reciprocating parts made to weigh the same, with the counterbalance sufficient to neutralize the inertia thrust at each center. There are thus four small inertia impulses at each revolution instead of the ordinary two large ones of the single engine.

Reserve Power for Auxiliaries

By W. H. Wakeman

There are many large and medium-sized plants in which the operation of the main engine depends on the action of auxiliary apparatus which is not equipped with reserve power of any kind for driving it, in case the regular means fails on account of an accident or the wearing out of some essential part.

For illustration, a certain mill that is run twenty-four hours per day is lighted by electricity supplied by a generator driven by a simple high-speed engine. If this engine is disabled by an accident the generator must stop, because no other method of driving it has been provided. This would leave the rooms in darkness, as the local electric-lighting company declined to supply current in case of such an emergency, and would not run wires into the plant for this purpose, as they wanted all of the job or none of it.

Again, a large power pump draws water for a certain manufacturing process. It must deliver water nearly every hour that the plant is in operation, or else the supply does not equal the demand; consequently, if it stops for any cause, the main engine must be shut down until the damage is repaired.

A certain plant which develops about 1000 horsepower is equipped with a stack sufficient for about 200. A fan is located between the boilers and this stack, and it is large enough to send the products of combustion to the low stack at a very rapid rate; but if the single engine which drives it is temporarily disabled no other means can be used to make it revolve, because none has been provided.

These illustrations show the advisability of providing more than one way to drive these important auxiliaries, especially when the comparatively small expense involved is considered.

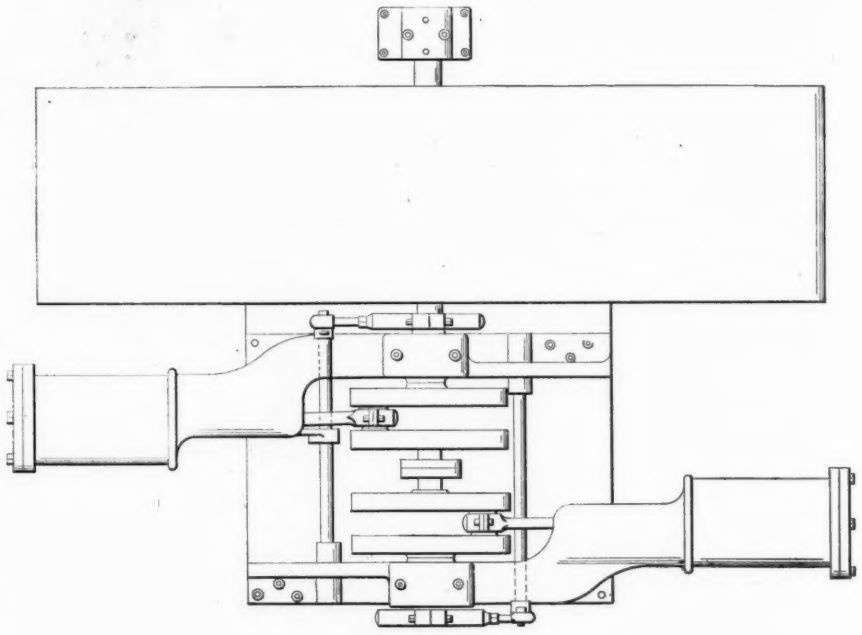


FIG. 1

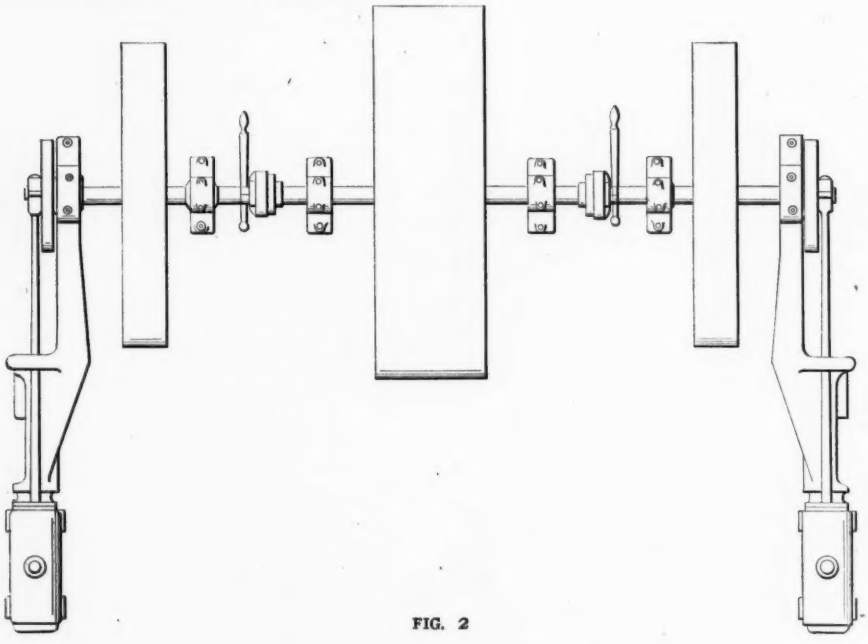


FIG. 2

Fig. 1 is a compact double engine which can be used as shown, or if one piston, cylinder, crosshead or connecting rod must be repaired, that part can be disconnected and the other used to drive part of the load, or carry the whole of it, if possible. Such an engine ought to be designed so that one cylinder will be large enough to do nearly all of the work; then, if both are used the liability of accident will be made less and the parts will prove durable. The engine as a whole will not show its greatest possible efficiency, but inasmuch as it develops only a small part of the power used this is of little consequence.

Fig. 2 occupies more space, but the design is excellent for several reasons. This shows two separate engines, with one flywheel that is common to both. It is not necessary to run one "over" and the other "under," as both must revolve in the same direction.

A substantial cutoff coupling is provided for each, with a suitable lever to operate it, by means of which either one or both of the engines can be disconnected with no delay whatever. They also make it practical to set the cranks in any desired position in relation to each other at pleasure, as it is only necessary to shut off steam from both cylinders and set one crank on either center. Release the other coupling, set this crank with the other, directly op-

posite to it, or at any point between these extremes. Throw in the lever and the cranks must remain in the given position.

A heavy balance wheel is provided for each engine for the following reason: The turning effect on the crank shaft in each case is not constant, but varies with the position of the crank pin, therefore the resulting strain on the cutoff coupling would be severe if it was not counteracted by the steady motion of the balance wheel. On this account a throttling, slide-valve engine, with a valve designed to cut off at seven-eighths stroke, is better than one of the automatic type, because its action is more nearly uniform in this respect.

Catechism of Electricity

914. *If the sparking is due to the brushes, how should it be remedied?*

If the brushes do not conform to the curvature of the commutator, or are not smooth, a strip of coarse sandpaper should be wrapped face upward once around the commutator, allowing it to lap a couple of inches over the first turn. By slowly turning the armature while the brushes are thus pressing on the sandpaper around the commutator, the contact surface of the brushes will be given the desired curvature. Then remove the coarse sandpaper and give each brush the necessary smoothness by drawing back and forth under it a short strip of fine sandpaper, keeping the back of the sandpaper throughout its length close against the surface of the commutator. Use a bellows to blow out the carbon dust from the commutator, brushes and brush holders and adjust the tension spring of the brush holders so the brushes are given the proper pressure upon the commutator as explained in 890.

Oil is sometimes applied to the commutator for the purpose of reducing the noise or chattering of the brushes and when much of it has been applied the brushes become sticky and readily collect dirt on their contact surface, producing sparking. They should then be cleaned by a cloth moistened in oil or benzine.

915. *Is there any simple way of ascertaining whether sparking is caused by brushes of too high resistance?*

Yes, this may be detected by the abnormally high temperature of the brushes. Such brushes should be replaced by others having a lower resistance.

916. *How is one to know if the brushes are at the neutral points?*

If there is sparking, and by shifting the brushes slightly around the commutator by means of the rocker arm the sparking is decreased, it proves that the brushes were not at the neutral points. In case, however, the brushes are not spaced as explained in 893, no amount of shifting will place them at the neutral points. They must then be readjusted before satisfactory results can be secured.

917. *What causes the commutator to become rough or uneven?*

Unless there is some end play to the armature shaft, allowing it to move backward and forward in accordance with the motion imparted to it by the belt, the

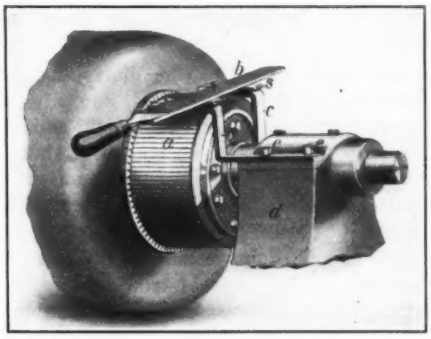


FIG. 280. A CONVENIENT FORM OF FILE REST FOR SMOOTHING THE COMMUTATOR

brushes will bear continuously on the same portion of the commutator and will in time cause it to become grooved and roughened. Hard particles in the carbon brushes will scratch the commutator. And it may be that the commutator has been turned out of the shop in a rough state.

Sometimes a bar in the commutator is of softer metal than the others and, by wearing, sooner causes the commutator to become flattened or eccentric. There will then be a gap between the brushes and the commutator at this point, resulting in sparking.

A high bar in the commutator, or a projecting strip of mica between the bars, which on account of its hardness does not wear down as quickly as the bars, will throw the brushes off the surface of the commutator during the rotation of the latter, and this will cause sparking.

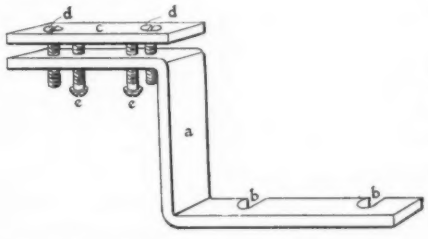


FIG. 281. DETAIL OF THE FILE REST SHOWN IN FIG. 280

918. *What is the best guide with reference to the condition of the commutator and brushes?*

The appearance of the commutator. If there is perfect contact between the brushes and commutator, the surface of the latter will take on a glossy brown or bronze appearance. A rough commutator, however, will generally announce itself by causing the brushes to make a chattering noise; this is particularly the case in high-speed motors. With an uneven commutator there will be a noticeable rising and falling of the brushes when the armature is rotating slowly.

919. *What precautions should be observed to keep the commutator in good condition?*

Wipe its surface occasionally with a soft cloth or piece of waste to remove accumulations of dust. Dust is a direct cause of poor contact between brushes and commutator; it is therefore responsible for much of the sparking, roughness and heating of a commutator. After removing the dust from the commutator, it is advisable to place a few drops of good machine oil or vaseline on a clean portion of the wiping cloth, and while the commutator is in motion, move the cloth slowly across it so the oil will spread lightly over its entire surface.

920. *If the commutator is rough, how should it be smoothed?*

Place a piece of fine sandpaper in a block of wood which has been hollowed out to fit the curvature of the commutator and press it against the commutator while the armature is in motion. If the commutator is very rough or unevenly worn, sandpaper does very little good. It is then necessary to use a file.

921. *Explain how to use a file in smoothing the commutator.*

The grade of the file used should depend on the work to be done, but it must be one that is least liable to be clogged by the copper. Oil must be used freely to avoid heating and choking, and to make the file cut well. The commutator must not revolve too rapidly and the file must be held properly. The hand which holds the file from slipping should be in a position where the commutator tends to pull rather than push the file. Failure to observe this rule may result in serious injury to the hand, or in a piece gouged out of the commutator.

To make a file safer and more serviceable for this work, a file rest should be provided. Without a file rest it is impossible to file the commutator surface level from end to end, and the flat places will not be taken out but made larger. There is also danger and difficulty in doing the work. Where there are several motors just alike, one file rest may be used for all of them.

922. *What kind of a file rest should be used and how should it be fastened in place?*

A convenient form of a file rest bolted in place is shown in Fig. 280. It consists of two pieces of iron, *c* and *c*, each provided at one end with an adjustable piece *s*. Each of the pieces *c* and *c* is attached to one side of the bearing *d*, and is held in position by the cap bolts *e*, etc. A file *b* is laid across the pieces *s* and *s*, which

are so adjusted that the file will just touch the commutator *a*.

The separate parts of the file rest are more clearly illustrated in Fig. 281, where *a* represents one of the pieces of iron, provided with slots *b*, etc., for the reception of the cap bolts. The other end is made adjustable by being provided with an extra piece *c*, whose hight is regulated by the screws *e*, etc. The piece *c* after having thus been raised to the proper hight is held in position by the screws *d*, etc. The part *c*, consequently, rests on the screws *e* and *e* and is held on them by the screws *d* and *d*. The latter screws are countersunk so that they will not be in the way of the file. The bar *a* should be of such dimensions that the pressure on the file will not cause it to move.

Driving up Bags in Steam Boilers

By M. Kennett

Among the many defects to which steam boilers are subject, there is none more common than that which is usually called a bag. These are sometimes called blisters, although a blister, or lamination, which is the correct name, is an entirely different phenomenon. In the days of iron boiler plates, laminations were quite common, but they are seldom found in modern steel plates, although occasionally met with, and the writer has noticed that they appear to be more common in the heavy plates which have recently been coming into more general use, than in the lighter ones.

A bag is caused by the sheet becoming overheated from some cause and forced out by the pressure. This overheating is usually caused by an accumulation of scale or sediment on the fire sheet, or it sometimes occurs around the blowoff at the rear. There are two methods of repairing a bag: one is to drive the metal back to its original position, and the other is to cut out the affected portion and put on a patch. Generally speaking, it is a great mistake to patch a boiler on this account unless the bag is unusually deep or very large. A patch is objectionable for several reasons. If it is of considerable size it weakens the shell, unless provided with the same design of riveted seam with which the longitudinal joints are provided, and this is usually impractical unless a half sheet or two-thirds sheet is put in. Owing to the difficulty of doing the work under unfavorable circumstances, the rivet holes often do not come fair when the patch is to be riveted up, and the drift pin is resorted to, with the result that the rivet holes soon crack out, forming what are known as fire cracks and causing a great deal of annoyance from the resulting leakage and corrosion of the sheets. Furthermore, it is much more expensive to put on a patch than it is to drive up a bag, even of considerable size.

The process of driving up a bag is so simple that there is little excuse for an engineer calling in a boilermaker to do it, yet frequently bags are allowed to remain in boilers for months at a time because the engineer dislikes to call in the boilermaker. It is not good practice to allow a bag to remain in a boiler, as it forms a pocket which is apt to collect more sediment and serious results are liable to follow.

To drive up a bag, the plate must be heated to a dull cherry red, and with a short-handled sledge hammer light enough to be handled easily and quickly it should be driven back. Care must be exercised to start around the outer edge and gradually work in toward the center, for if the work is started in the center, the plate is certain to be buckled and cannot be straightened without probably removing some of the tubes and driving it back from the inside. When a bag forms in a boiler, the metal is stretched and, of course, is reduced somewhat in thickness, and in driving it back the metal must be made to flow back to its original position. In order to do this it is plain that work must be started on the outer edge, gradually proceeding in toward the center as the metal is forced in ahead of the hammer. In the case of a very deep bag it is sometimes impossible to cause the metal to flow back sufficiently to prevent buckling and in this case it is a good plan to drill about a 1-inch hole in the center of the bag, so that the surplus metal will flow into this space, almost completely closing it by the time the sheet is straightened, after which it should be reamed out and fitted with a rivet.

The essential apparatus is a forge of some kind for heating the plate and a hammer. This forge must be such that it may be easily pushed aside out of the way when the required heat has been reached, for the thin sheet will cool quickly and no time can be lost. A style of forge which the writer has used to good advantage is made of a common galvanized-iron water pail as follows: About 3 or 4 inches from the bottom a number of holes are cut and into these pieces of ⅜- or ½-inch pipe are slipped to serve as grate bars. Below the grates another hole is cut and a short piece of ½-inch pipe inserted, to which a hose leading to a small bellows is attached for the blast. This will be found to be an excellent forge for the purpose, being inexpensive and so light that it is easily removed.

When ready to proceed with the work, remove the boiler grate bars, with the exception of one on either side, and lay a couple of boards across these to set the forge on. Fill the forge with charcoal and set it on the boards close up against the boiler shell and directly under the bag, and by means of the blast from the bellows bring the metal to a dull red heat. A small pile of charcoal placed in the bag inside the boiler will assist in this somewhat. Do not hurry the heating, and when the desired temperature is reached, remove the forge as quickly as possible and with the hammer begin driving up the sheet, working around the outer edge. Work until the metal is almost black and then heat it again, working in toward the center all the time and taking care not to drive the sheet up too far. It is better, if anything, not to drive it up quite far enough rather than too far, as the finishing may be done with a flatter as a final touch, using a straight edge to make sure there is no depression remaining in the plate. Of course this cannot all be done in one heat, and if the bag is very deep or large, a great many may be required. In one case a large bag required 80 heats, although not all in one spot.

Some engineers are of the opinion that if a sheet has once bagged and been driven back, it is apt to bag again. There is no good reason to suppose that this is the case, however, and the experience of a good many years in this line of work does not justify it. The metal is practically the original thickness, and unless scale or sediment of some kind is allowed to accumulate, there is no reason why the sheet should come down again.

A small amount of oil or grease will produce a serious bag and one difficult to repair, because it extends over a great area, and for this reason, as a rule, cannot be driven back. Furthermore, the patch required is so large that the usual single-riveted seam would seriously weaken the shell, and a joint similar to that in the longitudinal seams must be used. These are not practical where exposed to the fire, and the consequence is that half or two-thirds of a sheet must be put in to bring these joints above the fire line.

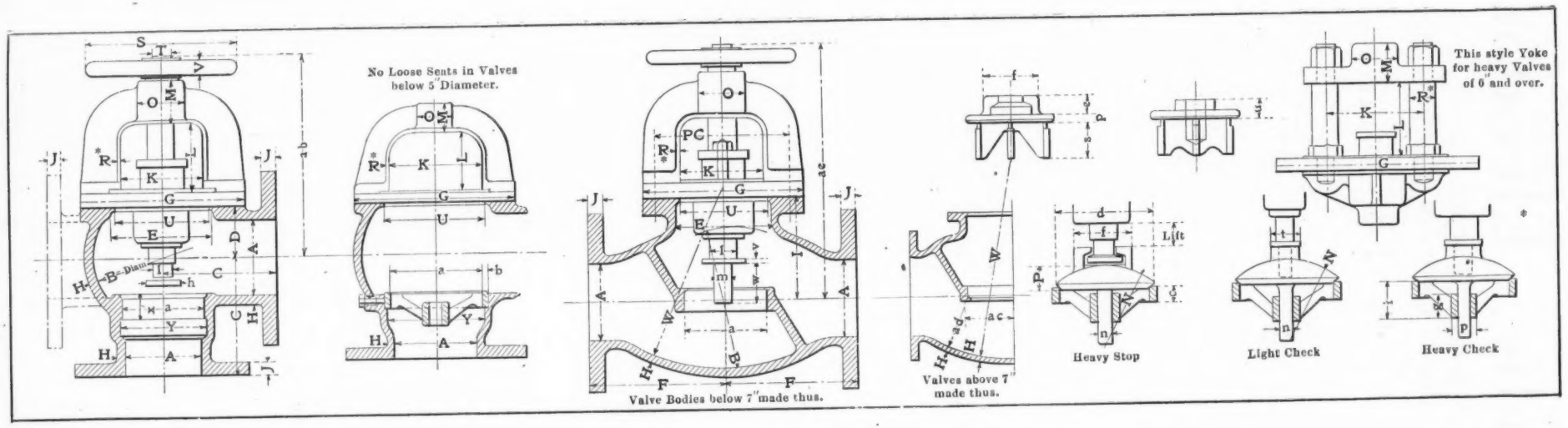
Dimensions of Valve Parts

By O. James

The table on the opposite page gives values which will facilitate the design of composition valves for pressures up to 200 pounds per square inch and for sizes from 1-inch to 9½-inch, with additional 11½-inch and 13-inch heavy sizes.

This table is excellent for those who have to design valves, as each figure or size has been carefully checked by drawing the valve either to full or half scale.

The angle, cross and globe valves, with the different combinations of stop and check valves, for both light and heavy pressure, have been carefully treated, as will be seen from the different sketches above the table. Provision has also been made for loose seats in all the valves above 5 inches in diameter.


No Loose Seats in Valves below 5" Diameter.
Valve Bodies below 7" made thus.
Valves above 7" made thus.
Heavy Stop
Light Check
Heavy Check
This style Yoke for heavy Valves of 6" and over.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	*R	S	T	U	V	W	Y	a	b	c	d	e	f	g	h	i	k	l	m	n	p	r	s	t	u	v	w	x	Lift.	Studs. In Bonnet.	Studs. Size in Bonnet.	Studs. No. in Yoke.	ab	ae	Per Cent. of Bolts in Bonnet.
1"	2	2⅞	3¼	1⅛	2⅞	3½	4⅛	5/16	1⅝	½	2	1⅛	2⅛	1	1¼	5/16	1/16	3½	⅜	1½	¼	3 1/32	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	4 1/16	5 5/16	2⅞
1¼"	2⅝	3¼	1⅛	2⅛	3½	4⅝	5/16	1 1/16	½	2	2 1/16	1		1¼	5/16	1/16	1/16	3½	⅜	1½	¼	3 1/16	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	5 1/16	6 5/16	3⅛
1½"	3	3¼	1 1/16	2⅜	3½	5	5/16	1 1/16	½	2	2 1/16	1		1¼	5/16	1/16	1/16	4	⅜	1½	¼	4	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
2" L	3⅜	4⅛	1⅜	3	4⅛	5⅝	5/16	1 5/16	½	2	2 1/16	1		1¼	5/16	1/16	1/16	4½	⅜	1½	¼	4	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
2" H	3⅜	4⅛	1⅜	3	4⅛	5½	5/16	1 5/16	½	2	2 1/16	1		1¼	5/16	1/16	1/16	4½	⅜	1½	¼	4	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
2½" L	4½	4½	1⅜	3⅜	4⅛	6⅛	5/16	1 5/16	½	2	2 1/16	1		1¼	5/16	1/16	1/16	5	⅜	1½	¼	4	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
2½" H	4½	4½	1⅜	3⅜	4⅛	6⅛	5/16	1 5/16	½	2	2 1/16	1		1¼	5/16	1/16	1/16	5	⅜	1½	¼	4	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
3" L	5⅜	5½	2⅛	4	5⅛	7	7/16	1 7/16	½	3	2 1/16	1		1¼	5/16	1/16	1/16	6	⅜	1½	¼	5	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
3" H	5⅜	5½	2⅛	4	5⅛	7	7/16	1 7/16	½	3	2 1/16	1		1¼	5/16	1/16	1/16	6	⅜	1½	¼	5	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
3½" L	6½	5⅝	2 1/16	4⅛	5⅛	7⅛	7/16	1 7/16	½	3	2 1/16	1		1¼	5/16	1/16	1/16	6	⅜	1½	¼	5	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
3½" H	6½	5⅝	2 1/16	4⅛	5⅛	7⅛	7/16	1 7/16	½	3	2 1/16	1		1¼	5/16	1/16	1/16	6	⅜	1½	¼	5	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
4" L	7⅛	5⅝	2 1/16	5⅛	6⅛	8⅛	7/16	1 7/16	½	4	2 1/16	1	4	1⅝	1		1/16	8	⅜	1½	¼	5	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
4" H	7⅛	5⅝	2 1/16	5⅛	6⅛	8⅛	7/16	1 7/16	½	4	2 1/16	1	4	1⅝	1		1/16	8	⅜	1½	¼	5	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
5" L	8⅜	6½	3 1/16	6⅛	7⅛	9½	7/16	1 7/16	½	5	2 1/16	1	5	2	1		1/16	9	⅜	1½	¼	5½	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
5" H	8⅜	6½	3 1/16	6⅛	7⅛	9½	7/16	1 7/16	½	5	2 1/16	1	5	2	1		1/16	9	⅜	1½	¼	5½	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
6" L	10⅛	7⅛	3 1/16	7⅛	8⅛	11	7/16	1 7/16	½	6	2 1/16	1	6	2	1		1/16	10	⅜	1½	¼	6½	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
6" H	10½	7⅛	3 1/16	7⅛	8⅛	11	7/16	1 7/16	½	6	2 1/16	1	6	3	1		1/16	10	⅜	1½	¼	6½	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
7" L	11⅛	8⅛	4 1/16	8⅛	9⅛	12⅜	7/16	1 7/16	½	6	2 1/16	1	7	2⅜	1		1/16	11	⅜	1½	¼	7⅛	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
7" H	11⅛	8⅛	4 1/16	8⅛	10⅛	13⅛	7/16	1 7/16	½	6	2 1/16	1	7	3	1		1/16	11	⅜	1½	¼	8	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
7½" L	12⅜	8⅛	4 1/16	9⅛	10⅛	13	7/16	1 7/16	½	7	2 1/16	1	7½	2⅜	1		1/16	12	⅜	1½	¼	8⅛	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
8" L	13⅜	9⅛	4 1/16	10	11⅛	14⅛	7/16	8⅛	½	8	4 1/16	2⅛	8	2⅜	1⅛		1/16	12	⅜	1½	¼	9⅛	1⅛	1⅛			1⅛	5/16	1 3/16	¼	1		5/16				1 5/16	⅜	1⅛	7/16	¼	5/16	1/16	6	6	⅜	4	6 5/16	7 7/16	3⅝
9" L	15	9⅝	5⅛	11	12⅛	14⅝	7/16	9⅛	½	7⅛	4⅛	2⅛	9	3	2	½	14	1⅛	10⅛	1 1/16	23	9⅛	10⅛	⅝	1⅛	11	1⅛	4	2⅛	2⅛	2 5/16	1⅛	2⅛	2⅛	2⅛	2⅛	2⅛	4⅛	3	4	2⅛	2⅛	16	⅝	2–1⅛	18 1/16	23 5/16	13⅞
9½" H	15½	10½	5⅞	11⅝	12⅞	15⅞	⅝	10⅛	1 1/16	7⅛	5 1/32	3⅛	10⅛	3⅛	2⅛	1⅞	16	1½	11 7/16	1 7/16	19½	10½	10⅛	⅝	1⅛	11	1⅛	4	2⅛	2⅛	2 5/16	1⅛	2⅛	2⅛	2⅛	2⅛	2⅛	4⅛	3	4	2⅛	2⅛	16	⅝	2–1⅛	18 1/16	23 5/16	13⅞
11½" H	19	12	6⅞	14½	15	19	1	12⅛	1	10⅛	6⅛	4	11½	4⅛	2⅛	2¼	18	2	14	1⅛	23	12⅞	12⅛	⅝	1⅛	13	1⅛	5	2⅛	2⅛	1⅛	1⅛	2⅛	2⅛	2⅛	2⅛	2⅛	5⅛	3½	5	2⅛	2⅛	14	1	2–2	20⅞	26⅛	16⅛
13" H	21	13½	7⅛	15⅛	16½	21	¾	13½	1½	12	7	4½	13	5⅛	2⅛	2	21	2½	15½	1⅞	25½	14⅛	14½	⅝	1⅛	14⅛	2	5½	2⅛	3⅛	3	2½	2⅛	1½	1⅛	2½	2⅛	6½	3	5½	½	4		3½	14	1½	2–2½	23⅞	29⅛	18⅛

*R special for heavy valves over 6" dia.

DIMENSIONS OF VALVE PARTS—SEE PAGE 152

The Plunger Hydraulic Elevator

Different Designs of the Lower Casting in "Standard" Plunger Elevators Described, with Illustrations of Piping Connections

BY WILLIAM BAXTER, JR.

Construction of Plunger Lower Casting

The lower casting *F* of the plunger is arranged to carry the guide brushes *H* that hold the plunger in the center of the cylinder. The construction of this casting and the way in which the brushes are held in place may be fully understood by the aid of the two horizontal sections, Figs. 295 and 296, taken on lines *N N* and *M M*, Fig. 291, and the vertical elevation, Fig. 297. The two sectional views also show a section of the cylinder *C*, to present more clearly the relative positions of the several parts. In Fig. 295 it will be seen that the brushes are held in grooves cast lengthwise of the casting *F*, and that these grooves are provided with flanges *a* along their inner edges, to prevent forcing the brushes too far in toward the center, and other short flanges *F'* to lock them in position. The brush back is made with short flanges *H'* that slide in back of the flanges *F'*. In putting the brush in position it is raised to the top of the groove and then pressed in until the flanges *H'* can be forced down back of the flanges *F'*, then the brush is driven down and a key *I*, Fig. 291, is put in above the brush to prevent it from jumping up. The brush is forced down until the back rests hard against the bottom *F''* of the side grooves in casting *F*. The keys *I* are not driven in endwise but sidewise, that is, toward the center of the casting

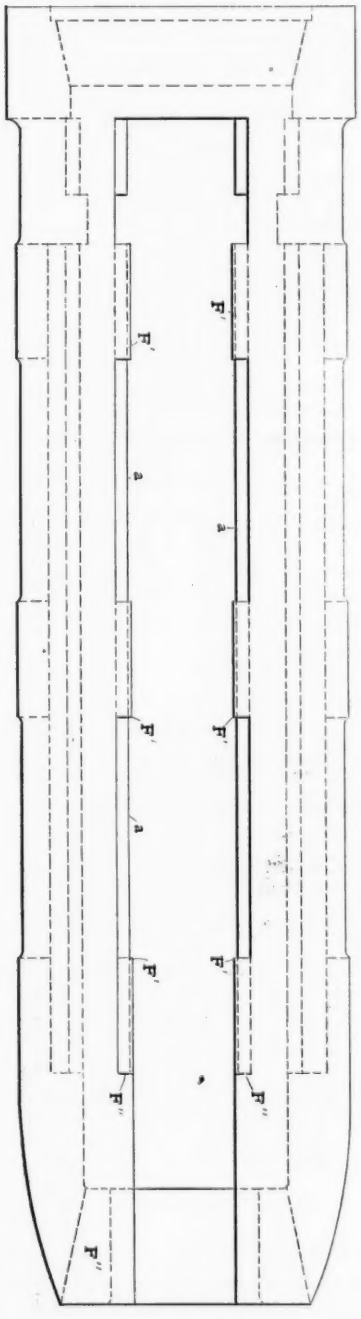


FIG. 297

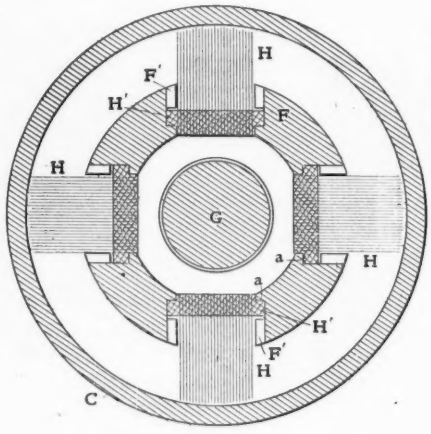


FIG. 295

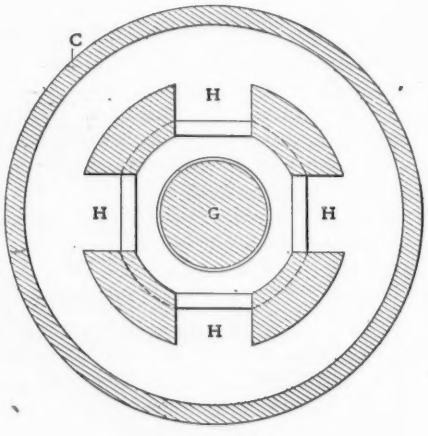
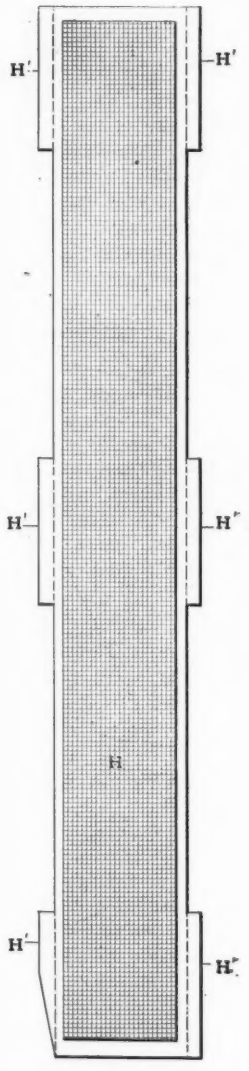


FIG. 296



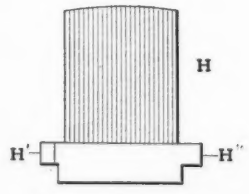


FIG. 298

and, when in position, are clinched so they cannot work out.

The shape of the brush is more fully shown by the aid of Fig. 298, which is a view looking at the face of the brush. The positions of the short flanges *H'* are clearly shown, there being six of them arranged in pairs. At the lower end the brush back is tapered off so as to facilitate getting it in the groove back of the flanges *F'* of the casting *F*. The space above the flanges *F'* is greater than the length of the brush flanges *H'*, so there may be no difficulty in pushing the brush into the proper position. The brushes are made of hard spring-brass wire, about No. 22 gage. The back is of babbitt metal and is cast around the wires to hold them firmly in position. The grooves in the casting *F*, into which the brush backs fit, are not machined, but are simply carefully cast, and the burs well cleaned off. As the brush back is soft, there is no difficulty in forcing it into place. If it should fit too tightly, it can be easily shaved off where it binds. When the brushes are in place in the casting *F* the water in the cylinder can reach the central space through the openings above and below the brushes and also through the joints between the brush back and the casting, as these are not tight fits.

Another Design of Plunger End

Another design of plunger end made by the Standard company is shown in Fig. 299, which is a vertical elevation in section, showing the plunger at its highest position, that is, in the position it reaches when the car is even with the upper floor of the building. The brushes in this case are held by the bolts *B*. A horizontal section through the lower end of the casting *F* is shown in Fig. 300, from which it will be seen that there are only three brushes. The design, Fig. 291, can also be made with three brushes, but Fig. 299 cannot be made with four, unless they are made considerably narrower and the bolts *B* are set farther away from the center. This design is simpler than that of Fig. 291, but it is not as perfect. In the latter if the car overruns the upper limit of travel the holes *B'* in the piece *B* will pass above the stuffing box and let the water in the cylinder flow out before the brushes reach the packing, but in Fig. 299 it can be seen that for the water to escape the plunger must run up until the part *F'* of the casting passes above the gland *E*, and this will carry the upper end of the brushes up into the stuffing. If the latter is of the cup type it may not be damaged to any extent, but if it is hemp it is liable to be pulled out of place. This plunger end cannot be used with the cylinder top shown in Fig. 289, unless there is so much head room above the elevator car, when even with the top floor, as to permit running it several feet higher before the casting *F* is high enough to permit the water to escape. If with this cylinder top the plunger should run normally as high as it is drawn in Fig. 299, the brushes would be carried up into the brass lining *D* and, by being bent back and forth at every trip, would soon become useless. The cylinder top in Fig. 299 is very much shorter, so the plunger can rise just as high as the plunger in Fig. 291 can rise in the top in Fig. 289, without running the brushes up into the bore of the casting.

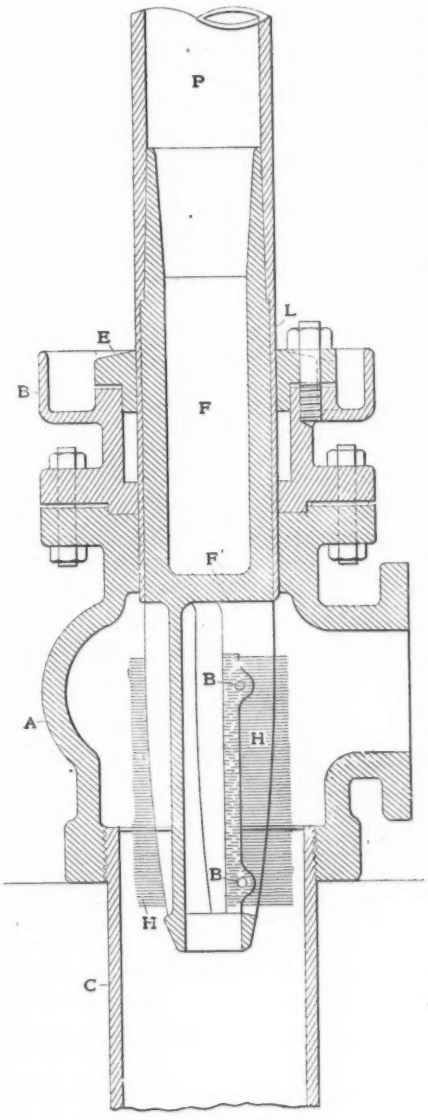


FIG. 299

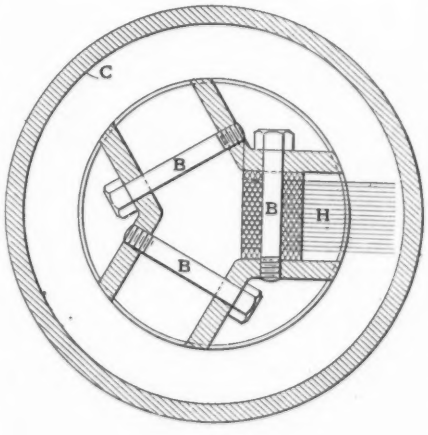


FIG. 300

Piping Connections

The pipe connections between the pump, tanks and lifting cylinder of a plunger-elevator system are generally very simple, but in some of the higher-grade passenger-elevator installations they are very elaborate. The arrangement most commonly used is shown in Fig. 301. In this diagram *A* represents the lower portion of the elevator car, *B* the plunger, *C* the cylinder and *D D* spring buffers provided for the car to rest on when at the lower floor. The main valve is shown at *F*, and is represented as of the simple rack-and-single-gear type. The discharge tank is at *G*, and *H* is the pressure tank. The water in the lifting cylinder *C* is discharged into the tank *G* through the pipe *L*, and from this tank the pump draws its supply through the suction pipe *M*. The discharge pipe *N* of the pump leads to the pressure tank *H*, and from the latter the water is carried to the lifting cylinder through the pipe *O*. In order to keep the necessary quantity of air in the pressure tank *H* means must be provided for forcing air into it from time to time, to replenish that which will inevitably escape in one way or another. In large installations, where several pumps and possibly tanks are provided, a small air pump is installed to furnish the compressed-air supply, but in smaller plants the pump *K* is arranged so as to pump air whenever necessary. The pressure tank *H* is provided with a glass water gage, to show the hight of water in it, and also with a pressure gage. In addition, a pressure regulator is used to stop the pump when the pressure in *H* rises to the maximum, and to start it when the pressure falls below the minimum.

Fig. 301 shows a system provided with a full complement of hand valves, three of these being marked *V*, *V'* and *V''*. There are two more, one in the pump suction and one in the pump-delivery pipe *N*. When all these valves are placed in the pipe lines the inspection of the several parts of the apparatus may be done with very little trouble. If it is desired to examine or renew the cylinder packing, all that is necessary is to run the car down to the lower floor and then close valve *V*. If the main valve is to be taken apart, the valves *V*, *V'* and *V''* are closed. To inspect the pressure tank *H*, the valve *V''* and the one in pipe *N* are closed. If repairs or inspection of the pump are required the valves in pipes *M* and *N* are closed. Thus with all the valves shown it is not necessary to draw water from as much of the system as has been stated in previous articles, in which it was assumed that a lesser number were used. If the discharge tank *G* is lower down than the discharge pipe *Q* the valve *V'* may be dis-

pensed with without impairing the system, and we may also add that the balanced main valve *F* can be replaced by one of the unbalanced type, such as shown in Fig. 287. The valve in the suction pipe *M* may also be discarded.

The Nature of the Volatile Matter of Coal*

By Horace C. Porter and F. K. Ovitz

In connection with the fuel investigations being conducted by the Technologic Branch of the United States Geological Survey, a special effort is being made to determine the chemical and physical structure of coal. The chemical investigation is being pursued along three special lines: (1) The chemistry of combustion in the furnace, that is, determining the chemical composition of the hydrocarbons given off during the process of combustion; (2) the hydrocarbons which are given off at different temperatures, starting with a normal temperature and determining the nature of the hydrocarbons given off at each of a series of successively higher temperatures from the normal to the temperature of the ordinary furnace, and (3) the hydrocarbons existing in the coal at normal temperatures to be determined by solution and subsequent analytical methods.

A paper presented by Dr. Horace C. Porter at the June meeting of the American Chemical Society, of which the present statement is an abstract, relates to the second of these three lines of investigation. Dr. Porter is in charge of the chemistry of the distillates of coal under the United States Geological Survey. The statement is in part as follows:

It is a familiar fact to retort-coke-oven and gas-works operators that the volatile products of coal are largely affected, both in quantity and character, by the conditions of temperature and rapidity of the rise of temperature in the coal, and by the conditions to which the products are subjected after leaving the coal. The usual laboratory determination of volatile matter serves almost universally as a more or less valuable indication of the coal's adaptability to industrial uses either for combustion, destructive distillation or gasification. The method for this determination is, however, an arbitrary one and does not duplicate closely that of any industrial operation, nor is the character of the volatile matter produced by the laboratory method known with any degree of certainty. Furthermore, the results by the laboratory method are very sensitive to varying conditions, and the influence of such variation on the character of the volatile products has not heretofore been the subject of extended study.

The importance of the role played by the volatile matter in all industrial applications of fuel is generally recognized. There are more heat units in the volatile matter in proportion to its weight than in the fixed residue. Pittsburg coal, of 30 per cent. volatile matter and 7 per cent. ash, has 36 per cent. of its heat value in its volatile matter, as shown by comparing the heat values of coal and coke. When coal is fired under a boiler, either by hand or mechanically, it first undergoes a process of distillation, and both the quantity and quality of the volatile products and the relative ease of their liberation are concerned very largely in the boiler efficiency and the production of smoke. It is reasonable to suppose that coals of different origin may yield volatile gases carrying different percentages of tarry vapors and heavy hydrocarbons and may on that account differ in smoke-producing tendencies. A knowledge of the chemical reasons why coals smoke in varying degrees, and why high volatile coals are hard to burn with maximum efficiency, is a necessary preliminary to the taking of intelligent steps toward improvement in these respects.

The gas producer for bituminous and low-grade fuels is coming more and more into favor. Here also the volatile matter in the fuel plays a very important role, since at the top of the fuel bed a process of distillation is continually going on. A certain proposed new type of producer will utilize high volatile fuels, such as bituminous coal, lignite, peat and wood, by passing the hot gases from the producer through the raw fuel in a series of preliminary chambers, thus distilling the valuable hydrocarbon gases, as well as ammonia, out of the fuel before it is charged into the producer itself.

Attention need hardly be called to the preëminent importance of the volatile matter of coal in the illuminating-gas and by-product coke-oven industries. It is of interest to note, however, the increasing favor accorded by the gas industry to the

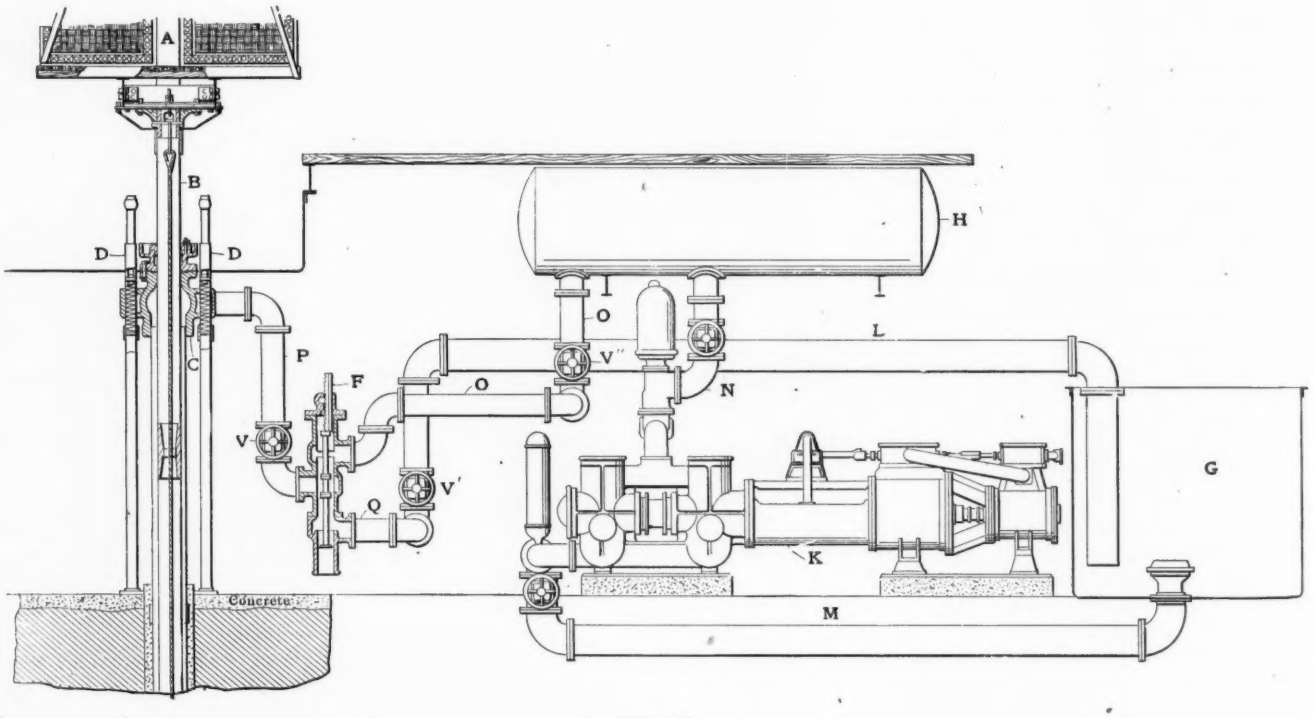


FIG. 301

*Presented with the permission of the director, U. S. Geological Survey.

vertical gas retort, as most successfully operated by the Bueb system at Dessau, Germany, and to explain that one advantage of this process lies in avoiding decomposition of certain valuable gases in passing over heated surface, as occurs in the ordinary processes, although at the same time a higher gas yield is obtained by using higher temperatures in the retort itself.

Purpose of the Investigation

The purpose of the investigation described in this paper has been: (1) To throw light on the nature of the volatile products from coal, and on the manner in which they are affected by the conditions prevailing during their formation, or to which they are subjected after formation; (2) to contribute, in the interests of smoke abatement, some data on the comparative amount and character of the gases and vapors distilled from different coals at low temperatures, a subject intimately concerned in the production of smoke; (3) to prove experimentally that the volatile product of coal is to some extent incombustible, and that the proportion of inert volatile varies in different coals; and, finally, (4) to show that the oxygen of coal is in many cases evolved in the volatile matter very largely in combination with carbon as CO and CO_2 as well as with hydrogen as water, thereby explaining in great degree the discrepancy found in these cases between the determined calorific value and that calculated by Du Long's formula.

Deterioration in Heating Value at Ordinary Temperatures

In connection with a series of experiments not yet completed, on the deterioration in heat value of various coals during storage under different conditions, a liberation of gas in remarkably large quantities was found in certain cases. About 25 pounds of bituminous coal of buckwheat size was stored in a five-gallon glass bottle closed with a rubber stopper, which was provided with glass tubes for removing gas samples. The bottles stood in the laboratory at a temperature ranging from 20 to 25 degrees. In some of the bottles the coal was immersed in distilled water and the interstices well filled with water by attaching a partial vacuum for about one hour. About 400 cubic centimeters of air remained above the surface of the water.

The gas liberated during these experiments consisted almost entirely of methane, with a very slight amount of CO_2, and no more than doubtful traces of CO and heavy hydrocarbons. No hydrogen could be detected by the palladium fractional combustion method. Whether this gas may properly be considered as volatile matter due to decomposition of the coal, or whether it is held in the coal as such by occlusion or absorption, cannot be decided without further study. The fact that the oxygen of the air surrounding the coal was rapidly absorbed without forming CO_2, indicates a change of composition in the coal. It is reasonable to suppose that a larger quantity of gas escaped between the mining of the coal and the starting of the experiments than was measured during the experiments. The measurement of quantity of gas formed is therefore of little value. The gas pressure in the case of one coal immersed, reached at one time 7 inches of mercury.

Volatile Matter at 105 Degrees Centigrade

A series of experiments, conducted primarily for direct weighing of moisture driven off from coal at 105 degrees, yielded results incidentally which showed the extent of the loss of substances other than moisture, principally CO_2 in small percentages.

TABLE 1. ANALYSIS OF COAL USED IN EXPERIMENTS.

	Moisture.	V.M.	F.C.	Ash.
Connellsville, Pa	1.10	30.67	60.35	7.88
Ziegler, Ill	7.67	30.38	54.32	7.63
Sheridan, Wyo	9.15	39.93	42.92	8.00
Pocahontas, W. Va	0.35	20.93	75.51	3.21

TABLE 2. AVERAGE RESULTS OF 10 GRAMS AIR-DRIED COAL.
(10 Minutes Heating.)

Coal.	Highest Tem. in Coal.	Tar.	Water.	Gas. (ccs)	Gas Composition. (Calculated to undiluted gas.)						
					CO_2	Illum.	CO	CH_4	C_nH_m (a)	H_2	N_2
10 minutes heating at 500°:											
Connellsville, Pa	335	....	....	8	30.0	0	6.5	6.5	7.0	0	50.0 (b)
Ziegler, Ill	325	....	....	90	14.8	0	5.3	8.0	....	0	71.9 (b)
10 minutes heating at 600°:											
Connellsville, Pa	441	4.9	3.2	190	6.3	8.2	5.9	36.9	23.7	2.0	17.0 (b)
Ziegler, Ill	440	6.8	13.0	173	15.7	7.0	14.4	19.0	22.2	2.8	18.9 (b)
10 minutes at 700°:											
Connellsville, Pa	562	11.0	3.5	583	3.0	7.2	5.4	44.1	17.7	13.5	9.1
Ziegler, Ill	545	7.8	14.0	471	8.5	5.1	13.7	59.6	0	1.1	12.0
Sheridan, Wyo	580	8.2	18.5	1020	28.8	3.7	20.0	18.6	6.8	15.1	7.0
Pocahontas, W. Va	599	4.2	1.9	675	1.9	4.4	3.9	44.4	16.1	28.5	0.8
10 minutes at 800°:											
Connellsville, Pa	687	12.6	4.5	1375	1.5	5.5	6.9	24.9	12.1	33.1	16.0 (b)
Ziegler, Ill	680	9.3	13.9	1251	3.8	3.8	16.0	27.7	6.1	33.7	8.9 (b)
Sheridan, Wyo	...	7.9	19.1	1780	19.8	2.7	21.4	14.1	4.0	30.0	8.0
Pocahontas, W. Va	...	6.5	2.4	1590	1.2	3.4	4.8	24.4	11.6	43.2	11.4

(a) Includes all higher paraffin hydrocarbons calculated as C_2H_6.
(b) Includes small amount of air.

TABLE 3. ABSOLUTE QUANTITIES OF SMOKING AND NONSMOKING PRODUCTS.*
(10 Minutes Heating.)

Designation of Coal.	Temperature.		Smoking Products.				Nonsmoking Gases (ccs).				
	Furnace.	Coal.	Tar, Per Cent.	Gas (ccs.) Illum.	Ethane, etc.	Total.	CO_2	CO	CH_4	H_2	Total.
Connellsville, Pa	500	335	....	0	0.6	0.6	2.4	0.5	0.5	0	3.4
Ziegler, Ill	500	325	....	0	0	0	13.5	4.7	7.2	0	25.4
Connellsville, Pa	600	441	4.9	16	46	61	12	11	71	4	98
Ziegler, Ill	600	440	6.8	12	39	51	28	25	33	5	91
Connellsville, Pa	700	562	11.0	42	103	145	18	31	256	78	383
Ziegler, Ill	700	545	7.8	24	0	24	40	64	281	5	391
Sheridan, Wyo	700	580	8.2	38	69	107	294	204	190	154	842
Pocahontas, W. Va.	700	599	4.2	30	109	138	13	27	300	192	532
Connellsville, Pa	800	687	12.6	76	166	242	21	95	343	458	917
Ziegler, Ill	800	680	9.3	47	76	123	47	200	346	420	1013
Sheridan, Wyo	800	...	7.9	48	72	120	355	381	254	534	1524
Pocahontas, W. Va.	800	...	6.5	54	186	240	19	77	390	691	1177

*10 grams of coal.

Volatile Matter at 500 to 1100 Degrees Centigrade

In studying the nature of the volatile matter at the medium and higher temperatures, 500 to 1100 degrees Centigrade, two sets of experiments were run, using a different apparatus in each. In one a 10-gram sample was heated in a platinum retort suspended in an electric resistance furnace maintained constant at the desired temperature, the gases evolved being collected by displacement of water in a bottle. No attempt was made in this set of experiments to duplicate the methods of industrial practice. The apparatus was designed with the idea of maintaining definite and controllable conditions which would yield results comparable with each other in experiments on different scale. The other set of experiments was run on a somewhat larger scale, heating 400 grams of coal in a cast-iron retort resting in a cylindrical electric resistance furnace, the tar, water, ammonia, CO_2, H_2S, and gas being collected in appropriate absorption apparatus and measured. Owing to the heavy nature of the retort and the large sample of coal the temperature in the coal could not be varied as easily in these experiments as in those using the platinum retort. Accordingly one set of conditions was adopted approximating as nearly as possible those of industrial by-product coke-oven practice, and a number of typical coals compared under these conditions. The object was rather to compare the different coals with each other under this set of conditions, than to determine absolutely the industrial by-product yields; and further, to determine the composition of the volatile matter from different coals under these conditions.

Series of Tests of 10 Grams of Coal

The series of tests on 10 grams of coal in a platinum retort, at various temperatures, is not yet completed, but has yielded sufficient results to show their approximate agreement with those obtained on 400 grams of coal, and also to indicate the composition of the gas produced from different coals in the early stages of heating at low temperatures. A thermocouple was inserted in the retort to determine the temperature under the surface of the coal itself. The tests were run in an atmosphere of nitrogen, which was passed through the retort until the exit gases contained less than 1 per cent. oxygen. The tar was collected in two 6-inch tubes of absorbent cotton heated to 100 degrees Centigrade and also weighed on the neck of the retort. The water was collected in a 5-inch $CaCl_2$ U-tube, and always contained a slight amount of light oil, driven over from the tar, causing an error of 1 per cent., or less.

Smoke Formation and the Composition of Low Temperature Gases

From the results given in Table 2 and in different form in Table 3, it may be seen that the low-temperature gases are high in illuminants and the higher homologues of methane, and low in hydrogen. Comparing the four coals at 700 degrees, where the gas begins to be formed in considerable amount, the Connellsville is the richest of the four coals in illuminants and heavy hydrocarbons and the Pocahontas the highest in hydrogen. The high CO_2 and CO from the Illinois and Wyoming coals accords with other experiments on these coals. The tar at 700 degrees is greater also in the Connellsville coal. The smokeless character of the Pocahontas coal may be connected more or less with the presence of considerable hydrogen in its gas at low temperatures, since the low-ignition point of hydrogen tends to assist in the burning of other gases present.

From the tables the bearing of these results on smoke formation may be seen. The smoke-producing constituents of the volatile matter are here considered as including tar, and the heavier hydrocarbon gases: benzine, ethylene and homologues of methune, calculated as C_2H_6. While at 440 degrees, in the coal, the Illinois coal, and probably also the Wyoming, has produced more smoky gases than the Eastern coals; at 565 degrees and higher the Connellsville produces much more. This accords with the finding in practice of greater difficulty in burning coals of the Connellsville type without smoke.

Conclusions Drawn from Experiments Made

1. Some coals liberate gas during storage, of a composition similar to that of natural gas, and some coals rapidly absorb oxygen from the air during storage without forming CO_2.

2. During drying in air at 105 degrees Centigrade, some coals lose appreciable amounts of CO_2, and most coals take up oxygen to a considerable extent, but none of those tested showed any considerable formation of combustible gases.

3. The nature of the volatile products, distilled from several coals at low temperatures in the early stages of heating, vary in different coals in accordance with their smoke-producing tendencies.

4. The volatile matter of coal comprises a considerable proportion of non-combustible matter, varying with the type of coal.

5. A modification is suggested of Dulong's heat-value calculation for coal, based on experimental results showing the distribution of oxygen between hydrogen and carbon.

Steel Belts for Power Transmission*

Steel belts, or metal belts, are by no means unknown, yet they are not generally used and are considered as particularly unadapted for heavy duty. Thus the development of steel belts for heavy power-transmission service in Germany is of more than passing interest. The subject of this article is the steel-belt development of the Eloesser-Kraftband-Gesellschaft, of Berlin.

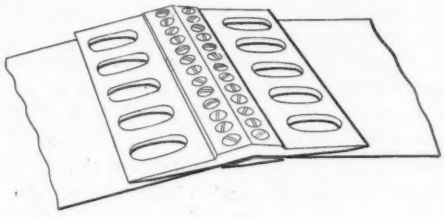


FIG. 1. JOINT OF A GERMAN STEEL BELT

As would naturally be expected, the joint of splice of a steel belt is one of the critical features. The joint construction used by this German firm is illustrated by Fig. 1. It consists of two steel plates, an under and an upper, between which the ends of the belts are joined. These plates taper from a thickened section at the center to comparatively thin edges. In the size illustrated, the upper plate is made with a series of holes in order to lighten it. Each of these plates is shaped to a circular arc, whose radius is equal to the radius of the smallest pulley on which the joint is to be used. Thus, for a given joint there is a minimum limiting diameter of pulley on which it can run, but no similar maximum limiting diameter; for a given joint can be used on pulleys of any diameter larger than the one to which the plates are particularly fitted.

COMPARISON OF ROPE, LEATHER-BELT AND STEEL-BELT DRIVE.

Item.	Rope Drive.	Leather-belt Drive.	Steel-belt Drive.
Breadth of belt space	6 ropes 45 mm. in diameter	500 m.	100 mm.
Breadth of pulley	380 mm.	500 mm.	110 mm.
Weight of pulley	1000 kg.	520 kg.	270 kg.
Weight of rope or belt	240 kg.	140 kg.	13 kg.
Total weight of drive	1240 kg.	660 kg.	283 kg.
Cost of pulleys	720 marks	400 marks	250 marks
Cost of ropes or belts	600 marks	1300 marks	750 marks
Total cost	1340 marks	1700 marks	1000 marks
Power lost in per cent	13 %	6 %	0.5%
Power lost in horsepower	13 h.p.	6 h.p.	0.5 h.p.

*Condensed translation.

The belt itself is made of a uniform quality of steel of an even thickness and is tempered. The ends are carefully brought together, fitted and soldered with a special solder that flows at a comparatively low temperature. This joining is then placed between the two plates that we have described, and these plates are fastened together by means of screws, as shown in the illustration, Fig. 1.

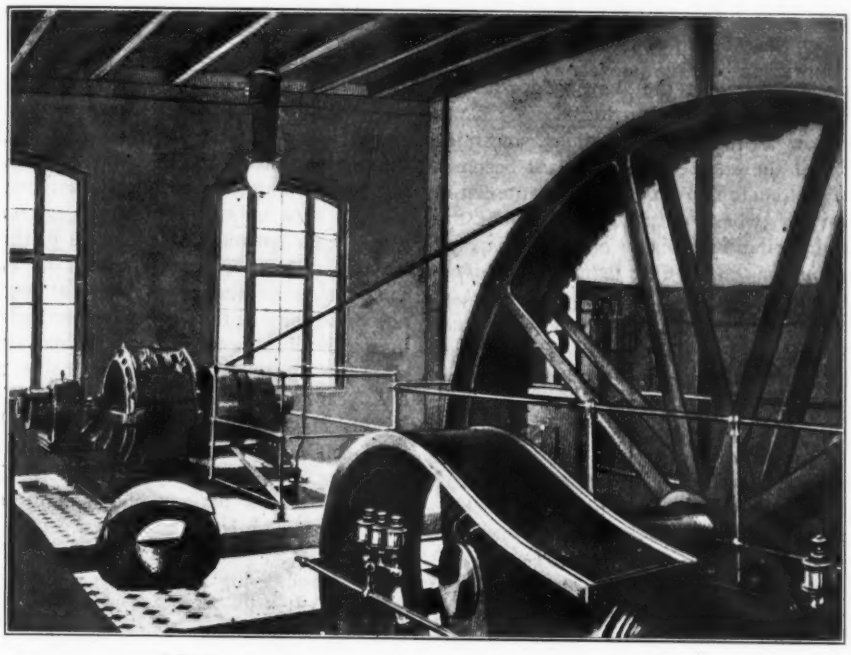


FIG. 2. A 250-HORSEPOWER STEEL-BELT DRIVE

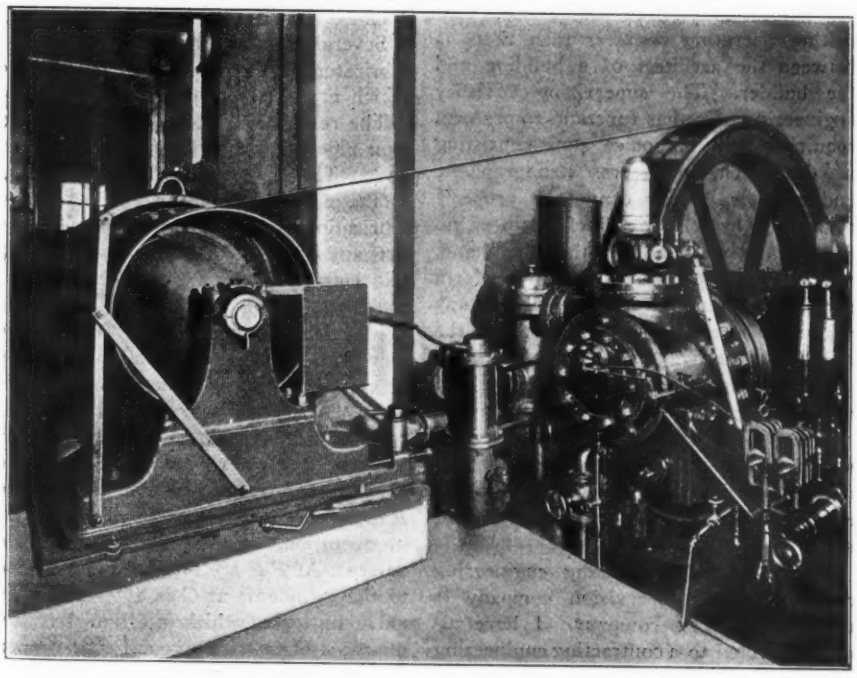


FIG. 3. A 160-HORSEPOWER STEEL-BELT DRIVE

Advantages

A number of interesting claims are made for these belts. Three of the most striking are: The small amount of slipping of the belt on the pulley, given in figures as less than 1/10 of one per cent., the narrow width of the belt compared with leather belts, the proportion being about 1 to 5, and the great speed at which these belts can be run, given as 100 meters per second, or say 19,000 feet per minute. This latter figure is striking if we compare it with the factor usually given for leather belting as 4000 feet per minute. It is very common to run these steel belts at a speed of 50 meters per second, or, roughly, 10,000 feet per minute.

Other minor advantages which are really dependent upon the three major ones that we have pointed out are: A narrower and lighter pulley for given service, a lighter and smaller shaft, a reduction of the strains upon bearings (thereby a reduction of the size of bearings and in many cases—especially on electrical machinery—the elimination of outboard bearings), a saving of room through a reduction of the general dimensions of machinery, avoidance of temperature and humidity effects (thereby a lessening of the required attendance) and, in case the belt is applied to existing pulleys, the possibility of using the pulley face for other belts. This last feature is particularly true of portable engines.

Because of the high permissible speed these belts have been adapted in many cases to electrical machinery, both generators and motors, and to gas engines. They have also been used for driving belts in machine shops and other manufacturing establishments. The table gives comparative data between a rope drive, a leather-belt drive, and steel-belt drive for 100 horsepower, transmitted by pulleys 10 meters, 30 feet apart, at a speed of 200 revolutions per minute and a diameter of 1 meter, 3 feet. The metric measurements in the table are not translated into English measurements because the table is of comparative interest only.

Representative Installations

Referring to the half-tone illustrations, Fig. 2 shows a drive on a steam engine at the plant of Ludwig Sudicatis & Company, Berlin, from a 250-horsepower steam engine to an electric generator. The width of the steel belt is 100 millimeters, or say 4 inches; the width of the leather belt which was removed, and which is seen lying on the floor, is 600 millimeters, or say 24 inches. The striking feature of this illustration is the narrowness of the belt.

Fig. 3 shows a drive in the plant of the Berliner Elektrizitatz-Lieferungs-Gesellschaft, Berlin. It transmits 160 horsepower, and the breadth of the belt is 100 millimeters, or say 4 inches. The leather belt that is replaced was 280 millimeters wide, or about 11 inches.

The Australian consul at Naples states that steam engines and boilers are being built in Italy, and the demand for the latter from abroad has almost disappeared. Steam engines are still imported from Switzerland and Great Britain. The introduction of suction-gas engines has almost eliminated the use of steam engines and locomobiles in industrial enterprises. Suction-gas engines are built by a few large firms in Italy, but they are also imported from Great Britain, Switzerland and Germany. Petroleum and benzine motors are imported from Great Britain, United States, Germany, but only in small quantities as yet; the demand may, however, increase as a result of the reduction of duty on petroleum. Steam pumps are imported from Great Britain and Germany.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Extraneous Supervision of Power Plants

I trust that you will give me space for a self-discussion of your editorial on "Extraneous Supervision of Power Plants":

First—Let me state that I recognize the fairness of your presentation of the subject, but I do not agree with your conclusions.

Second—I wish to call attention to the fact that I purposely modified, in the same paper in which the original matter was published, viz., the *Record and Guide*, my remarks about graft in the engine room. By this I mean that I publicly stated that there were a great many high-class engineers who recognized the evils of the graft system and the system of receiving commissions on supplies and repairs as fully as I did, and they further recognized the fact that an honest engineer who would not take graft was placed at a serious disadvantage when applying for a position, because other engineers who were not honest and who expected to take graft and commissions were able to offer to take the position at a very much less salary.

It is, of course, a matter of common knowledge and of individual knowledge that in a great many plants in this city, the purchasing agents, whether they be engineers or others, exact commissions on purchases. It is not the amount of these commissions that is the serious drawback, but it is the fact that a fair judgment as to quality of the supplies is absolutely precluded. It is also a fact that in many instances repairs are undertaken, which would not otherwise be necessary, merely for the purpose of obtaining commissions; and in such cases the employer not only pays the commission made by the repairman to the engineer, but he spends probably nine times the amount of this commission in an unnecessary repair. How can an honest engineer, expecting to receive nothing more than his salary, compete with an engineer who counts on these commissions and graft as part of his salary; and is it any wonder that where such conditions do exist the Edison company is able to come in and shut down a plant?

It is my honest opinion that with a properly and honestly managed plant, whether operated under engineering supervision or not, there is no chance at all of shutting the plant down after it is once installed, but with dishonest or incompetent management the shutting down of a plant is a foregone conclusion.

Now as to your conclusion; your idea is that the engineer of the plant becomes an automaton, a mechanical automaton you say, whose strings are pulled by the engineering supervision office. *This conception of the relations between the supervision company and the operating or chief engineer is entirely erroneous.* It must be evident to anyone who is familiar with the operation of the modern complex plant that any attempt to operate this plant without a high-grade trained engineer on the premises would be disastrous. It is the writer's opinion, and one that he has stated frequently, that unless the chief engineer worked in sympathy with the supervising engineer, no good results can be accomplished; and the chief engineer of the plant is, in my estimation, one of the most important members of the organization of the supervision company, and I see no reason why there should be any more conflict between the chief operating engineer and the advisory consulting operating engineer than there is between the architect of a building and the builder. The supervising advisory engineering office has functions to perform requiring a whole office staff consisting of draftsmen, engineers, stenographers, auditors, etc., which cannot be properly performed by a single chief engineer no matter how good; and on the other hand, a chief engineer has duties to perform which could not be performed by any organization unless located directly on the premises operated.

A large plant has its advisory consulting engineer, and if the small plant is to compete with service from the central station, it must have at its disposal engineering services and purchasing services equal to those available to the central stations.

You speak of contracting engineering companies; the supervision company is not a contracting company. I have always objected to a contracting engineering company, as I think it essential that the interests of the employer and of the advisory engineer be identical and not opposed, as they are to a certain extent where a contract for operation is entered into. That is, the supervising engineering company should be paid for its services the same as the architect is paid, and the plant should be operated to the best interests of all concerned.

Another point of importance in connection with the relations between a supervision company and the operating engineer is that efforts to effect improvements are noted, and the capable, honest engineer is sure of advancement as well as steady employment. As examples of this, may be noted the chief engineer of the Langham, who started as assistant engineer; the chief of the Weil & Mayer buildings, who has been promoted from one plant to another paying better inside of one year; the chiefs of Reisenweber's, Acker, Merrall & Condit's, Langsdorf's, Saks & Co., all promoted from assistant engineers to their present positions; in fact nine-tenths of our chief engineers have graduated from assistants.

P. R. Moses.

Engineering Supervision Company.
New York City.

Multiple Feed Lubricator

Several months ago I constructed a lubricator, a sketch and description of which are herewith submitted.

The reservoir, Fig. 1, is made of 5-inch iron pipe, 15 inches long, capped at both ends. The sight feed is attached directly on the pipe. There are two sight feeds for lubricating two different steam cylinders, but any number of sight feeds may be attached. There is a gage glass to denote the hight of oil; *C* is a ¾-inch cross valve connecting the bottom of the reservoir with the pressure pipe *M*, which can be connected to any steam pipe; it is preferable, however, to connect this pipe direct from the main steam pipe so that pressure is always available. The valves *D D* are for feed regulation. The valves *E E* must be kept closed at all times while in operation, as they are ordinary gage valves. At *F F* are oil-feed pipes leading to the cylinders; at *G* is a ½-inch filling valve, on top of which is a funnel *H* containing a brass-wire screen for a strainer; the top of this funnel is closed with a leather cup to keep out dust and dirt. At *I* is a ¼-inch air vent to be opened when filling and also when draining out the water. Valves *J* and *K K* are to drain the body and sight feeds; all drains are piped together. At *L L* are sight-feed glasses. The part *M* acts as a ¾-inch condenser and pressure pipe. The highest point is 6 feet above the top of the oil

reservoir. At *N N* are ⅛-inch pipes on the inside of the reservoir, which extend to the top of the body of the lubricator; they connect to the feed-regulating valves *D*, the shanks of which are tapped out, and a short nipple and elbow screwed in and the long vertical pipe screwed into the elbow. To fill, after once in operation, it is only necessary to close the valve *C* and the feed valves *D*. The valves *E E* serve another purpose beside holding the gage glass and, as mentioned, must be kept closed, as the pressure would immediately force the oil through them to the oil-feed pipes and empty the lubricator.

Where the steam cylinders are quite a distance from the lubricator, it would be better to run the oil-feed pipe from the top of the reservoir directly to the cylinder and place the regulating valve as in Fig. 2. It is also well to have the oil-feed pipes covered, especially if exposed to a cold draft, or where the pipe is rather long, as it may cause trouble by choking with cold oil. When placing the independent sight feed, Fig. 2, directly on the cylinder or steam pipe, the same advantage of forcing any amount of oil directly into the cylinder in case of necessity is had, but in a different way.

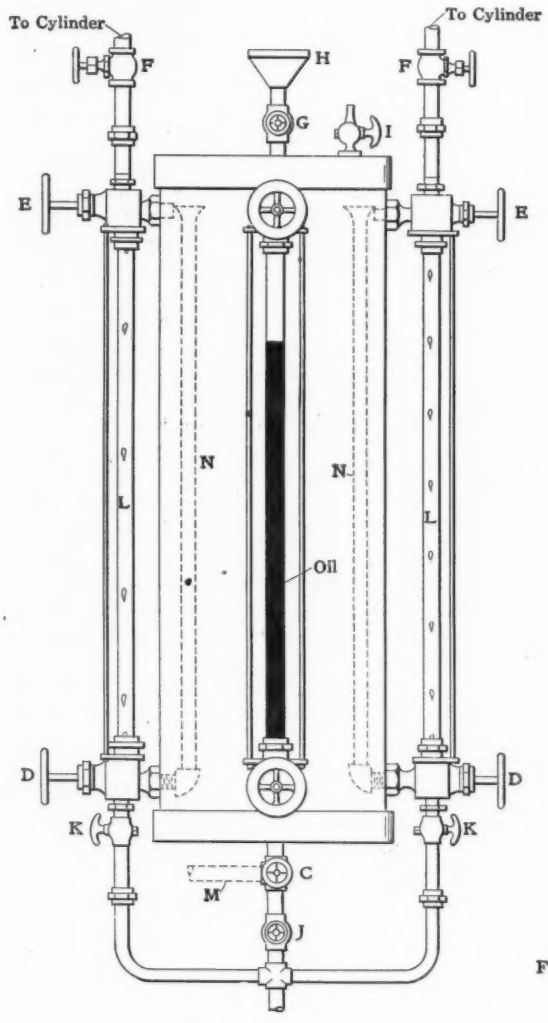


FIG. 1

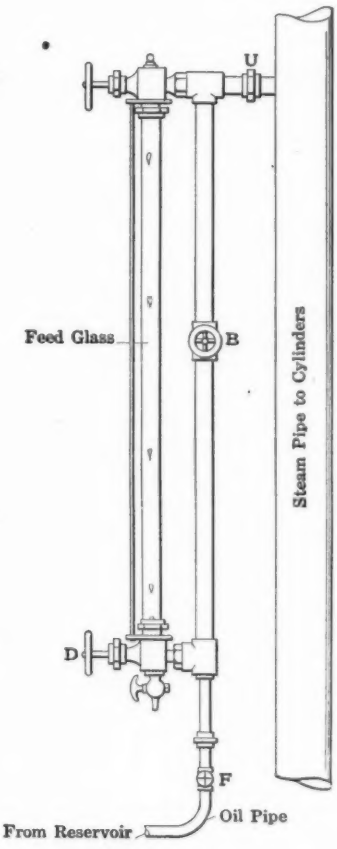


FIG. 2

MULTIPLE-FEED LUBRICATOR

This action, however, is taken advantage of when first starting the engine or pump; or, in case a cylinder becomes dry for want of oil, any amount of oil can immediately be forced to any cylinder by opening the valve *E* for a few moments and then closing it again.

Another advantage of this lubricator is that any pipe, glass or drain can be blown out without interfering with any other part, as long as there is steam pressure.

In Fig. 2, is seen a steam pipe leading to the engine or pump; *B* is a valve placed in the oil-pipe line *F*, and is of any convenient size.

To operate, close the valve *B* and slowly open the top valve so as to fill the glass with water and leave it open. Then open the regulating valve *D* and adjust the oil feed. To flood the cylinder with oil, open the valve *B* for a moment.

A. J. SHAD.

Cincinnati, O.

Mr. Sheehan's Motor Trouble

The cause of the trouble reported by Thomas Sheehan on page 1011 of the December 15 number may be readily explained by the fact that the motor in question had a compound winding on its field magnet. Such a motor has two field windings, one a shunt winding connected across the line, and the other a series winding which carries the entire armature current. It is customary to connect these two field windings so that they assist each other in building up the magnetic field. In this case, however, the series winding must be connected so as to oppose the shunt winding.

What happened was this: When the workman started the beater the clutch on the shaft was not thrown out quickly enough to prevent the motor from shutting down. It stopped, as stated by Mr. Sheehan, while still connected to the line. That would cause the motor to take a very heavy current through the armature and the series field winding, and the result would be that the voltage of the generator would drop off to a very low value. The motor at a standstill put almost a short-circuit on the generator, and under these conditions the generator could not hold its voltage. The low voltage greatly decreased the strength of the current in the shunt field winding of the motor, while the current in the series winding was much stronger than normal; consequently, the series field winding was the stronger and reversed the polarity of the field magnet, causing the motor to run backward as soon as the clutch on the shaft was thrown out. The reversed direction and the heavy current would cause the motor to spark viciously. The current would very speedily drop off as the motor gained speed, but the reversed direction of rotation would still account for the sparking, as the brushes were undoubtedly shifted backward somewhat for the correct direction of rotation.

The high speed was due to the fact that the motor was running as a series motor without load. It is to be further noted that the shunt field winding of the motor would gradually build up and as it opposed the series winding would still further weaken the magnetism of the poles. The voltage of the generator did not rise at once when the motor became unloaded because the field strength could not build up instantaneously.

If the attendant had allowed the motor to run a little longer it is possible that the voltage would have risen sufficiently for the shunt field winding to overpower the series field winding and cause the motor to stop and reverse again. But before doing so it would undoubtedly have reached a dangerous speed, so that the operator did the correct thing in opening the switches.

It is to be noted that this does not ac-

count for the reversal of the meters, inasmuch as the large current would still flow in the usual direction as there was no action to reverse the generator. In fact, there seems to be no reason why the polarity of the meters should have been changed, unless the ammeter was of such a design as to become reversed by a large current. It is in fact very questionable whether the meters actually did reverse, for it is frequently reported that meters have become reversed when as a matter of fact the pointers are only stuck at one end or the other of the scale. I am not casting any reflection on the accuracy of Mr. Sheehan's statements, but merely suggest that an instrument may appear to be reversed when a more careful investigation will show that this has not happened. In the instance under discussion the voltmeter pointer would drop back practically to zero and might easily become caught at the lower end of the scale, due to the sudden swing, while the ammeter pointer would go off the scale at the upper end, and might stick there.

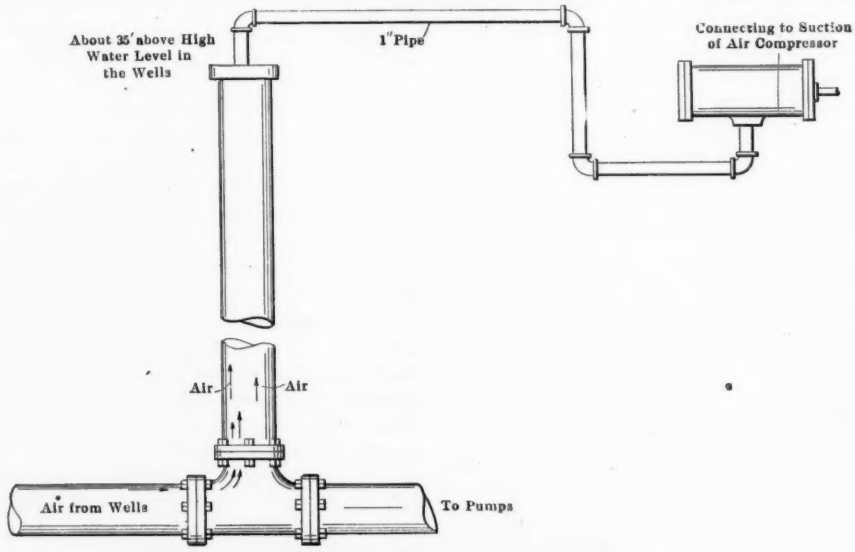
It might be of interest to Mr. Sheehan and the motor attendant to note that the connection of the series field winding as it now stands is not usually employed except where it is desired to maintain a very close speed regulation through all changes of load. The opposing influence of the series field winding causes decreased ability of the motor to carry a heavy load, and, just as has happened in this case, when the load becomes too heavy the motor will stop. By reversing the connections of the series field winding and making it assist the shunt winding the motor will be better able to stand up under severe load conditions and will also have better starting torque. The drop in speed from no load to full load will be greater than it now is, but in all probability this will not be objectionable.

S. A. FLETCHER.

Wilkinsburg, Penn.

Air Pump Arrangement in a Pumping Station

While visiting a large pumping station recently, my attention was called to the arrangement shown herewith. The main suction line connects to 115 driven wells, the water level of which is ordinarily from 10 to 12 feet below the pumps, which are located in a circular pit about 25 feet below the level of the engine-room floor.



AIR-PUMP ARRANGEMENT IN A PUMPING STATION

During the dry weather of last year the water level fell to such an extent that, on account of so many wells being connected, considerable air was drawn into the suction, causing the pumps to pound badly when any attempt was made to run them above half-speed.

Just outside the pump connections on the suction line was a tee having a vertical pipe 10 feet long capped on the end, which acted as an air chamber. This pipe was extended up level with the engine-room floor, making about 35 feet above the highest water level in the wells.

The top cap was drilled for a 1-inch pipe, to connect to the intake of a small steam-driven air compressor, which was not being used at the time. By running the compressor (or vacuum pump, as it was in this case) at a moderate speed, a 26-inch vacuum was maintained on the 1-inch line.

As all air coming from the well connections would naturally follow along the top of the suction line, it would pass up into the vacuum chamber and be removed through the compressor, leaving a solid body of water entering the pumps. Since making this arrangement no trouble has been experienced in operating the pumps at their full capacity.

S. KIRLIN.

Fort Worth, Tex.

How to Set Brushes

There has been a discussion for some time relative to the proper way to set brushes on motors and generators. There seems to be a wide difference of opinion regarding this matter, which is probably due to the fact that each person in relating his experience has reference to the type of brush holder with which he is familiar, and as different types of holder require different treatment, there arises an apparent contradiction of one writer by another.

Some brush holders require brushes set *with* the direction of rotation of the commutator, and others require brushes set *against* the direction of rotation. In Fig. 1 is shown a brush holder of the first class, which must always be set as indicated by the arrow. If set in the opposite direction trouble will surely ensue, as an inspection of the figure will show, because the surface of the commutator and the brush would form a toggle joint, and the brush would tend to dig into the commutator and either break itself or bend the brush rigging.

In Fig. 2 is shown a brush holder of the other type which is used by one of the large manufacturing companies. This brush is set against the direction of rotation but an inspection of the cut will show that there is, in this case, no tendency for the brush to dig into the commutator surface.

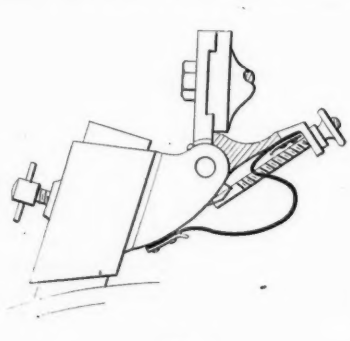


FIG. 1

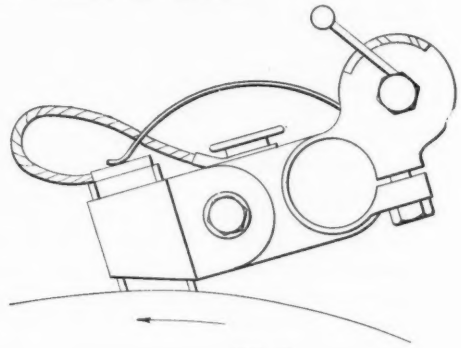


FIG. 2

From the foregoing it is seen that no hard and fast rule for brush setting can be made, but each type of holder must be treated as recommended by the manufacturer of that particular type.

R. H. FENKHAUSEN.

San Francisco, Cal.

Capacity of Rectangular Tanks

By the use of the accompanying diagram the capacity of rectangular tanks may be found. Tables giving the cubic contents of this style of tank for 1 foot of depth will be found in many handbooks, but it is necessary to multiply this value by the hight of the tank to find the total capacity. The diagram also serves as a ready means for securing the dimensions of tanks of equal capacity.

The lines running upward from the lower left-hand corner to the right represent the width of the tank, and are so labeled. The lines running upward from right to left represent the hight of the tank. The lower margin gives the length of the tank in feet. The left-hand margin gives the capacity of the tank for 1 foot in depth, while the upper margin gives the total capacity.

As an example, suppose the capacity of a 6x9x8-foot rectangular tank is required. The method of solving this problem is shown in dotted lines on the diagram. Starting with the length, 9 feet, project upward to the 6-foot line, across to the 8-foot line, then upward to the top margin, where the answer is found to be 3240 gallons.

The given capacity of a tank equals 3500 gallons, its hight is 7 feet and the width 7 feet; find the other dimension: Project down from 3500 on the top margin to the hight line, marked 7, across to the width line 7, and then downward to the lower margin, where the length is found to be 9.55 feet.

Suppose the capacity of a tank equals 3000 gallons, then the dimensions of tanks of this capacity are found by the chart to be 5x9.5x8.45 feet, 6x8x8.35 feet, etc.

JOHN B. SPERRY.

Aurora, Ill.

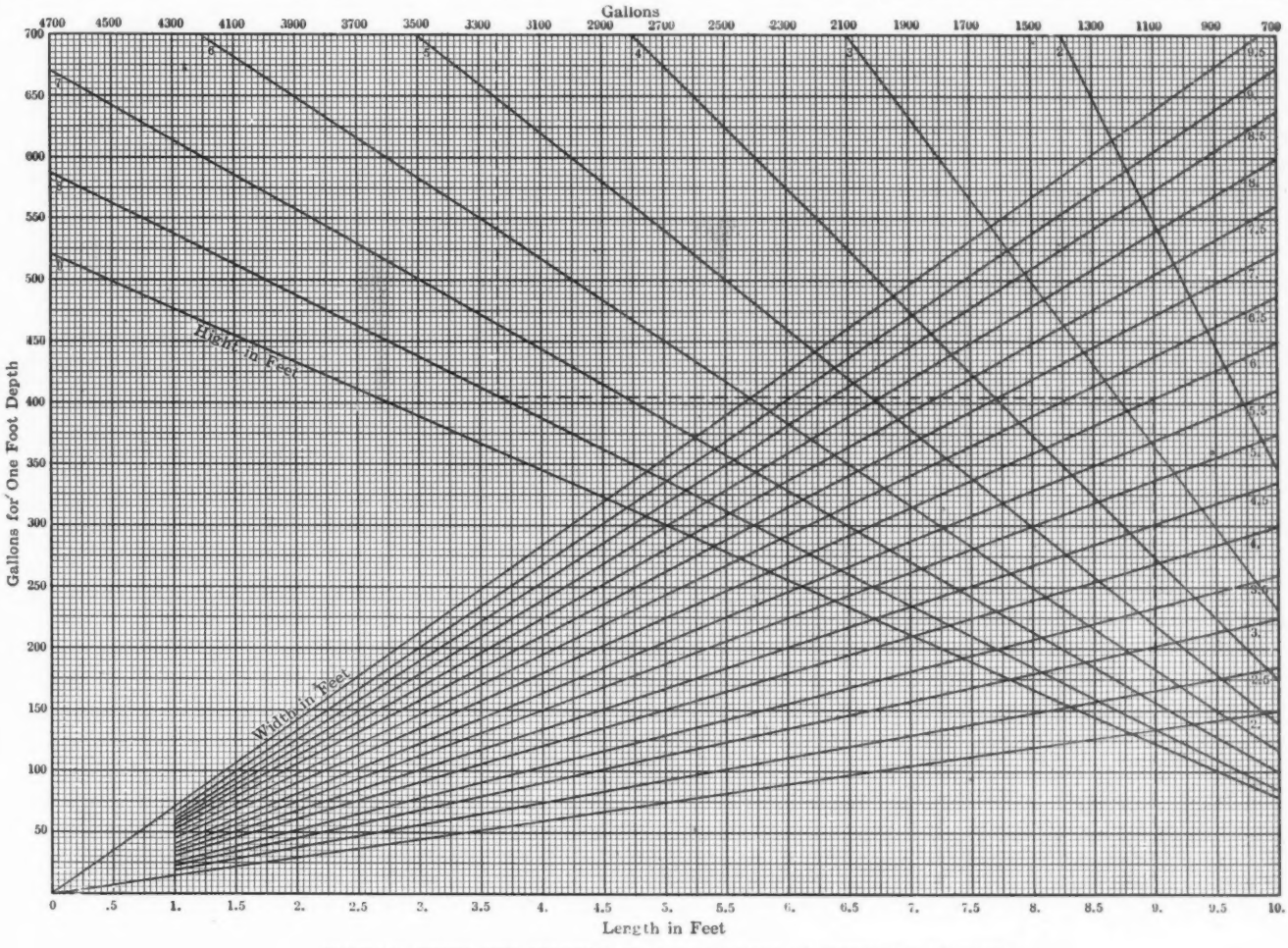


DIAGRAM GIVING THE NUMBER OF U. S. GALLONS IN RECTANGULAR TANKS

Cast Iron Crosshead Pins

F. L. Johnson stated, in an article in the December 8 issue, that "somehow it looks as if the whole family of engine makers has gone steel crazy and are using steel for everything under the sun, even where a moment's thought would show that for some purposes steel is the worst possible material that could be selected, and crosshead pins is one of these."

As the best engine builders are using steel for pins, and steel pins can be worked at nearly double the pressure permissible with iron running at the same speed (Kent, page 802), I should like to ask Mr. Johnson to give his reasons for his statement, as I believe the same will be of interest to many engineers.

G. HECKLINGER.

Portland, Ore.

[Mr. Hecklinger's letter was sent by Mr. Johnson to Mr. Sawyer, whose remarks were quoted in the article in question, and he commented as follows: "What I said about the use of steel referred entirely to crosshead pins, and my critic turns to Kent on crank pins, an entirely different matter, and the comparison made there is between steel and wrought iron, and not between steel and cast iron. What I had in mind for crosshead pins was cast iron, which is not considered at all by the 'best engine builders' referred to by Mr. Hecklinger. These same engine builders make steel pins and bronze boxes for the crossheads, but in the crank boxes they put babbitt. Under heavy pressure and the slow movements of the surfaces in the crosshead bearings, lubrication is difficult and deficient, and unless made of proper materials the wear is rapid. The coefficient of friction is greater between brass and steel than between any two metals used in machine construction, while with one of the members made of cast iron the coefficient of friction is low. Cast iron is more easily lubricated than any other metal, hence an amount of lubrication that

is ample for a cast-iron pin may be, and usually is, insufficient for a steel pin. Not long ago I saw a cast-iron crosshead pin that had been in daily use for more than 25 years and the most careful measurements failed to detect any wear. I have never known of a hot or cut pin where cast iron was used, but have personally had several cut steel pins. I would use cast iron for crosshead pins because they run with less friction, are more easily lubricated, wear better and give less trouble than steel pins."—EDITORS.]

Engine Wreck Prevented by Quick Action

At our street-railway power station two cross-compound vertical engines are

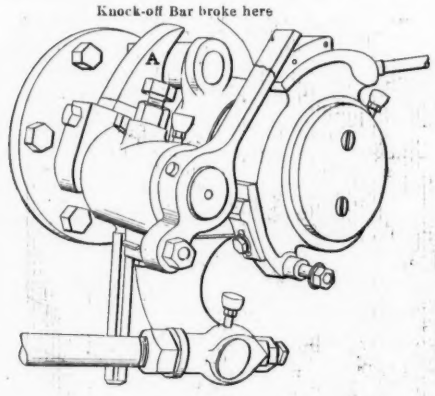


FIG. 1

equipped with the type of releasing gear shown in Fig. 1. Not long ago the knockoff bar broke, as shown in Fig. 1, and, dropping down, became wedged against the knockoff lever, as shown in Fig. 2, forcing the governor down to its lowest running position, when the engine would take steam at seven-eighths stroke.

The governor belt being intact, the idler pulley kept the lugs in contact with the

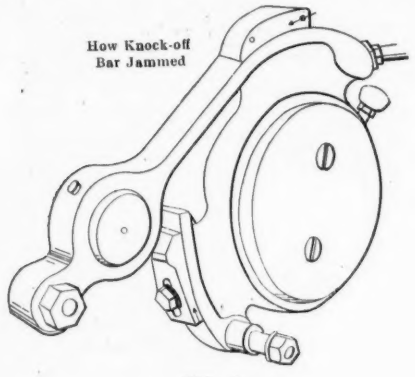


FIG. 2

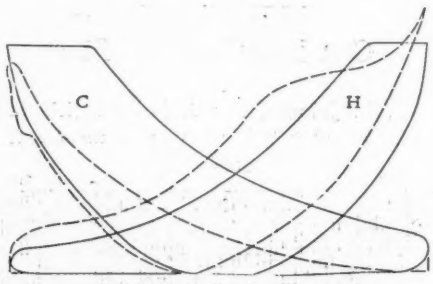
governor collar and prevented the governor from assuming its lowest position and bringing the safety cams into action. Of course, the engine started to race and only quick action prevented a wreck. The throttle-valve wheel is handled from the floor and the engineer was on the valve deck. Knowing that there was no time to come down in the ordinary way, he jumped from the upper deck to the floor and shut the throttle.

THOMAS SHEEHAN.

Pittsfield, Mass.

Faulty Indicator Diagrams

In a recent number, under the heading "Faulty Indicator Diagrams," a contributor asked what could be done to benefit the engine. The trouble is due to incorrect valve setting, and the only thing to do is to set the valves correctly.



CORRECT AND INCORRECT DIAGRAMS

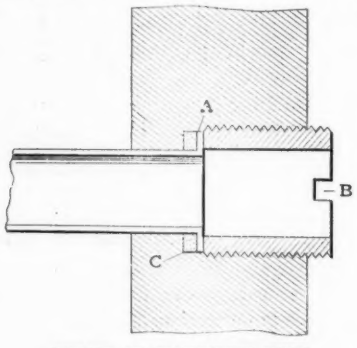
I believe the problem can be solved by plotting correct diagrams on the faulty ones to compare them. The illustration shows the full lines indicating the correct diagrams; the dotted lines the faulty ones.

E. J. FARKAS.

Detroit, Mich.

Condenser Tube Packing

The tubes of a surface condenser began to leak badly, and were repaired in the following manner: The tubes were annealed on one end and flanged over leaving a collar *A*. (See sketch.) The holes in the condenser head were bored and tapped with a radial drill press. Brass glands were made in the usual manner by the aid of an adjustable box tool, and the edges rounded.



REPAIR OF CONDENSER TUBE

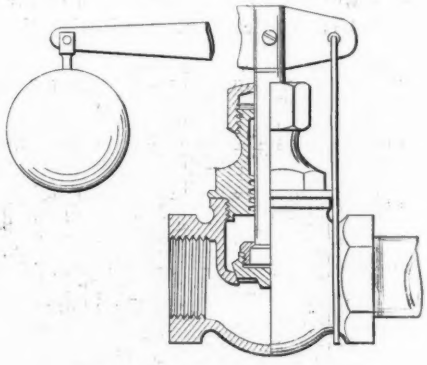
One end of each condenser tube was packed by placing a rubber gasket *C* underneath the collar of the tube, and the gland screwed down against the face of this collar. The other end of the tube was packed in the same manner as waterglass tubes, allowing the tube to pass through the gland, squeezing the rubber against the outside of the tube. This made an excellent job and for six years the condensers have not leaked.

SAMUEL KINSEY, JR.

Peoria, Ill.

A Homemade Relief Valve

Herewith is described the way I made a relief valve to put between a pump and a water motor. I got an old globe valve and, removing the stem, filed the threads off to make a smooth surface. A slot for the lever arm was then cut, and a hole drilled and tapped to receive a 5/32-inch button-head machine screw, as shown in the illustration. The lever was cut from a piece of 3/32-inch band iron and the



A HOMEMADE RELIEF VALVE

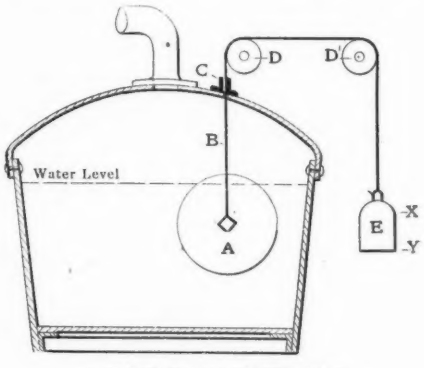
necessary holes drilled in it. The fulcrum was made from a piece of No. 8 wire, bending it in the middle where it passes through the lever, and securing it around the valve body, as shown.

A. C. GRANT.

Middlefield, O.

An Old Haystack Boiler

The article on the above subject on page 1039 of the December 22 number



A FLOAT-STONE WATER GAGE

interested me greatly. It seems a pity to let those old fellows rust but, of course, it is impossible to preserve all of them. The method of running the vertical seams straight instead of staggering each tier seems to me to be wrong. Mr. Maplethorpe says:

"There is no sign of gage cocks or water gage."

It is peculiar, for the only part of the half-tone which stands out by itself is probably all that is left, *outside* the boiler, of the water gage.

On top of the haystack boiler is an upright which supports a sheave. If this is what I take it to be then it is part of a water gage much used in the early days.

When Puffing Billy was used at Killingworth colliery in England, that is subsequent to 1813, these haystack boilers were used for raising steam for the winding engines. There was as a general thing either a platform or the brickwork built up around the boiler to near the hight of the water level. The engineer with his wooden-soled clogs would ascertain the level of the water by kicking the plate. The sound would tell him whether there was water or steam behind the part of the plate where he was tapping it with his foot. This was much the same as we tap a plastered ceiling or wall to find where the joists or studding are.

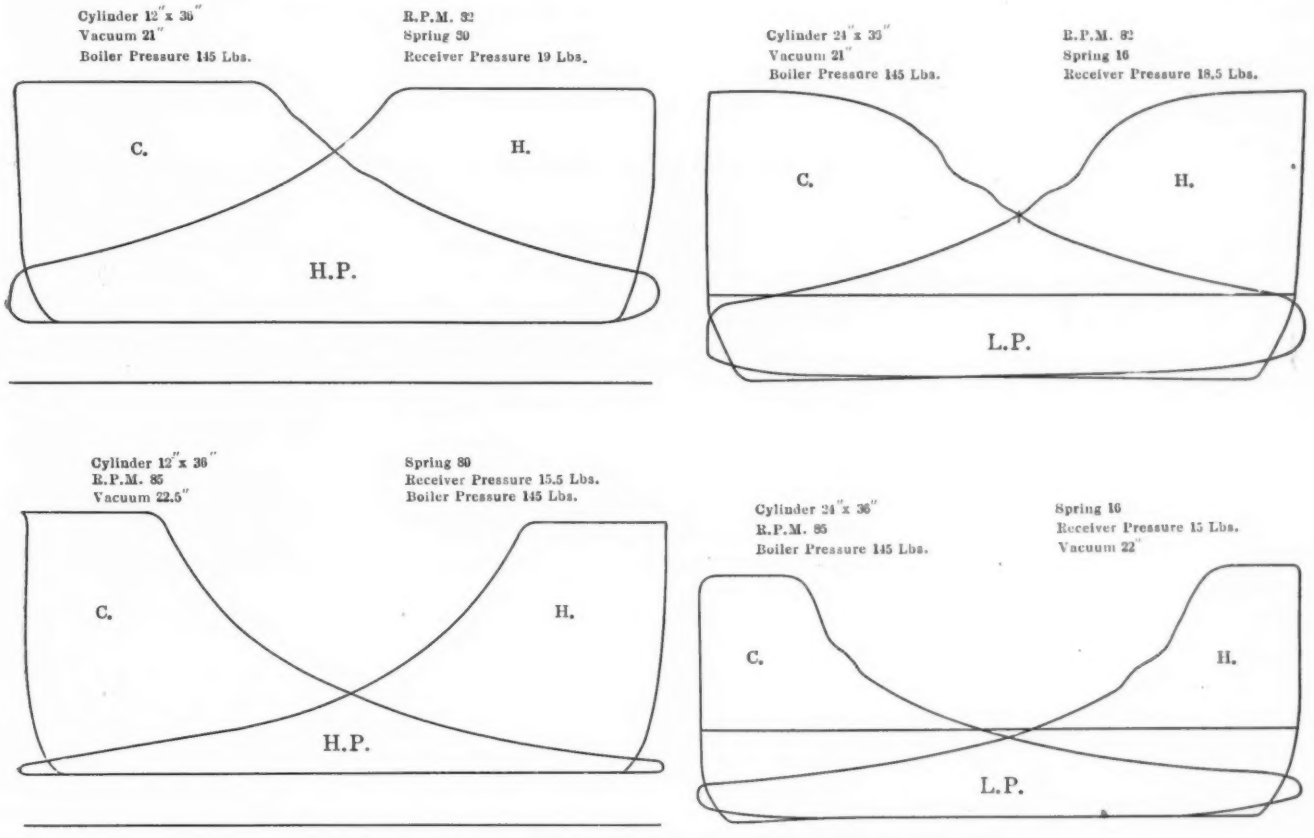
A later invention in the way of a water gage was evidently used on the haystack boiler referred to. It consisted of a piece of stone somewhat like a grindstone. Grindstones when worn small were often used for this purpose. These were called "float stones" and their application is shown in the accompanying cut in which *A* is the float stone and *B* is a copper wire, one end of which is secured to the float stone and the other end to the iron weight *E*. The wire passes up through the stuffing box *C* and over the two sheaves *D* D_1, *D* being the sheave shown in the half-tone. As the water "boiled down" the heavy float stone would lift the weight *E*. The relation of the weight *E* to the marks *X Y* showed the engineer where his water was.

If Mr. Maplethorpe will crawl inside that old boiler he will probably find an old float stone.

It is merely a question of specific gravity. In air the stone weighed more than the iron weight *E* but with the stone partly immersed in water the stone would ballance the weight *E* in air.

E. A. DIXIE.

New York City.



DIAGRAMS FROM A 12 AND 24 BY 36-INCH CROSS-COMPOUND CONDENSING ENGINE

Compounding Engines

Recently in a letter entitled "Horsepower of Compound Engines," W. H. Wakeman says that some steam users think a compound engine develops twice the horsepower that a simple engine does, and that somebody ought to show them their mistake.

If it is not to increase the horsepower, why are engines compounded to develop more work by using again the steam that has done work in the high-pressure cylinder?

Mr. Wakeman also challenges Mr. Ball to produce indicator diagrams to show that it can be done. For fear Mr. Ball will not discuss such a question I submit the accompanying diagrams from a Corliss 12 and 24 by 36-inch cross-compound condensing engine. While these diagrams do not figure quite the same horsepower on each side, I have taken diagrams where there was only a slight difference in the work done in both cylinders.

I should like to know the object in putting a larger cylinder on an old engine frame when, by compounding, the steam is not only saved but the extra work is practically done by the low-pressure cylinder for the same cost. It is true that by putting a larger cylinder on an old engine frame more power is obtained, but it will require more steam to do the extra work.

GEORGE W. HARDING.

Lexington, Neb.

Gas and Boiler Explosions

Charcoal can absorb about forty times its own volume of "nitrous oxide gas" (the deadly agent in explosion). How can M. R. Cahill reconcile this fact with his theory for the explosion of his boiler, which was made of *charcoal* iron, as stated on page 1088 of the December 29 number?

J. E. TERMAN.

New Haven, Conn.

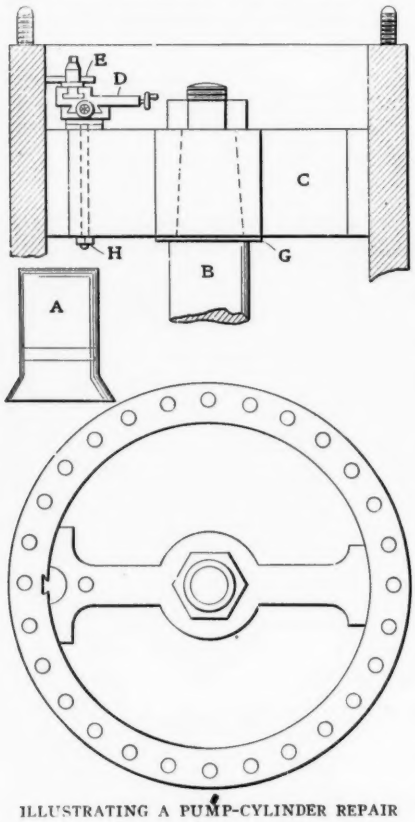
[Nitrous oxide is "laughing gas."—EDITORS.]

Pump Cylinder Repair

An accident happened to one of the high-pressure cylinders of a pumping engine, and as the pump was needed almost any moment, the owners looked for the quickest way to repair it.

The trouble was due to one of the sections of packing ring breaking and cutting a score the full length of the cylinder about ¾ inch wide and 5/16 inch deep.

Several machine-shop superintendents wanted to rebore the cylinder, but as this would necessitate a new piston, and



ILLUSTRATING A PUMP-CYLINDER REPAIR

considerable time, we gave up this idea and resorted to the following method:

An iron casting *C* was bored to fit the piston rod *B*, and turned to a nice sliding fit in the cylinder. A slide-rest *D* was fitted to the top of this casting and held with the bolt *H*.

With this arrangement we planed a dovetailed slot in the cylinder, the full length, raising the piston rod by water pressure and lowering it by allowing the water to escape from the lower cylinder. The slot was planed as far down as could be with the slide rest on the top of the casting, and then we finished by placing the slide rest on the under side. Next a bronze strip was prepared the exact size of the slot and driven to the bottom of the cylinder. As this strip was rather slender and long it was soldered on a reinforcement at *A*. A washer *G* was placed under the casting *C*, so we could loosen the nut holding it, allowing it to turn without binding on the taper end of the rod.

By swinging this casting in a circular motion it was possible to plane off the excess metal to the same arc as the cylinder. This made an excellent job, and took but a short time to finish.

There was quite a discussion as to whether to cut the bronze strip off flush with the end of the cylinder or cut it off a little short, to allow for expansion, but finally it was decided that the best plan was to cut it off the same length as the cylinder and let the metal take up itself. This cylinder was opened again after running about one year and if the exact place where the strip was had not been known, it could not have been detected.

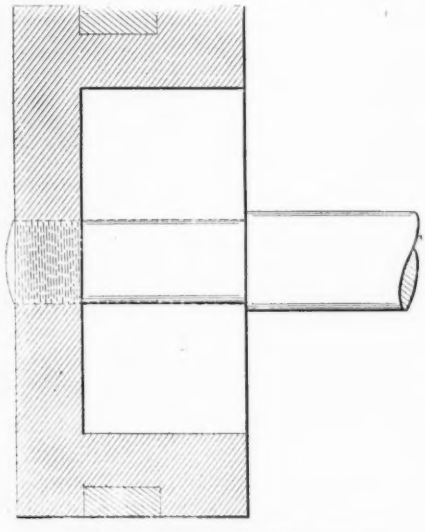
SAMUEL KINSEY, JR.

Peoria, Ill.

What a Substitute Piston Did

A very dangerously designed piston rod which came to my notice recently partly wrecked a 26x51-inch Corliss engine, running 56 revoluions per minute.

The piston was 6 inches thick. The end of the piston rod was threaded for 1½ inches and engaged with a corresponding thread in the 1½-inch cast-iron follower plate, there being no thread in the piston spider. Instead of securing the rod with a nut, it was left flush with the follower plate. The strain on the cast-iron thread caused it to strip, allowing the piston to deliver a blow against the head, cracking it in several places, and as the momentum in the wheel forced the rod back it caught on the piston, breaking the



HOW THE PISTON ROD WAS PUT IN

crank. The cylinder was cracked by one of the thin steel packing springs being jarred out of place and wedging under the piston. A piece was broken out of the back side of the piston and was afterward found in one of the exhaust ports.

It may be said in favor of the engine builders that this piston and rod were not of their design. The original piston and rod having been put out of business by a dose of water, this freak piston was put in without the builders' knowledge.

R. F. BLANCHARD.

Fitchburg, Mass.

Indicator Stop Device

This device for taking indicator diagrams is somewhat unusual. It consists of a ½-inch board, 42 inches long and 6 inches wide. The upper end swings on a

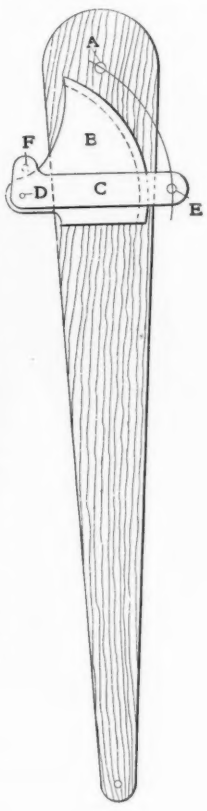


FIG. 1

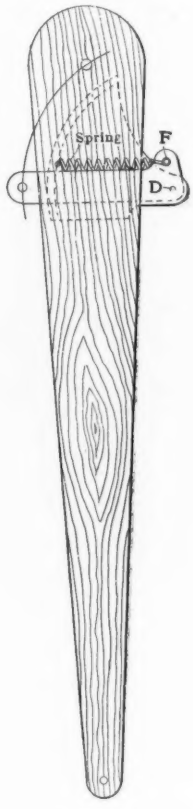


FIG. 2

pivot at *A*, Fig. 1; the lower end has a projection which swings in a block, sliding on a spindle fastened to the cross-head. A piece of iron *B* is placed over a ½-inch board of the same shape, but does not come quite to the edge at the curved part. Both are fastened to the main board. A lever *C* is attached at *D* with a joined spring at *F*, as shown in Fig. 2.

The indicator cord is attached to a projection at *E*.

When desiring to put a new cord on the indicator diagram, a string running to another projection back of *E* may be pulled through the groove left between the main board and the iron *B*, which will bring *E* in line with *A*, and all motion of the indicator will cease.

In making this device it is necessary to locate the point *E* down from *A* according to the length of diagram desired and to place *D* so that when *E* is pulled up it will come exactly over *A*.

BERT E. EVANS.

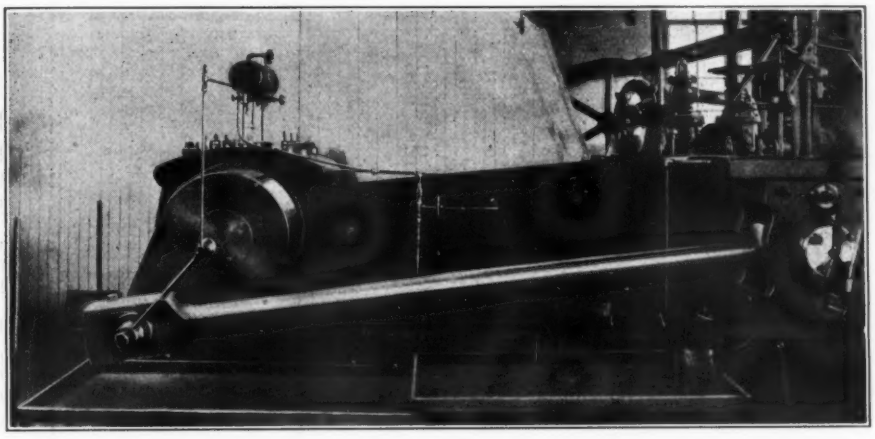
Springfield, Mass.

An Oiling Device

The accompanying photograph is of an oiling device attached to the frame of our engine. The oil tank above the main pillow block was originally a piece of 6-inch iron pipe. It has a head welded in at either end. A gage glass is attached to show the amount of oil in the tank. The front oil guard of the engine has been removed so as to give a better view of the arrangement.

The pump is fastened directly to the front side of the engine frame and connected to the rocker arm from which it derives its motion.

After the oil has lubricated the various bearings and drops into pans, as shown,



THE OILING DEVICE ATTACHED TO ENGINE FRAME

it runs into the filtering tank just below the pans, where all sediment is removed and the oil used over and over again.

F. H. Janney.

Minneapolis, Minn.

Calculation of Cooling Surface for Surface Condenser

The article by C. L. Hubbard, on condensers, in the December 22 issue, attracted my attention, and I wish to offer some comments on the calculation of cooling surfaces. Attention should be directed to the analysis of the formula

$$S = \frac{W\ L}{180\ (T - t)},$$

where L is the latent heat of the steam at condenser pressure. This, at the outset, assumes that the steam is saturated at the condenser pressure but, as will be shown, this is not so.

Assume an engine exhausting to the atmosphere against a back pressure of 2.3 pounds, gage, and also an engine using 30 pounds of steam per indicated horsepower at a pressure of 80.3 pounds, gage. The total heat for 30 pounds is, therefore,

$$30 \times 1180.7 = 35{,}421$$

B.t.u. One horsepower corresponds to 33,000 foot-pounds per minute, or

$$\frac{33{,}000 \times 60}{778} = 2542$$

B.t.u. per hour.

The heat in the exhaust equals the total heat taken in minus the heat transformed into work. Using the above figures, then,

$$35{,}421 - 2542 = 32{,}879$$

B.t.u. *above 32* degrees.

Looking in the steam table, it is seen that the total heat in the steam at 2.3 pounds gage pressure is 1148.9 B.t.u., and

$$1148.9 \times 30 = 34{,}467$$

B.t.u. The error is, therefore,

$$\frac{34{,}467 - 32\,879}{34{,}467} = 0.046,$$

or 4.58 per cent., and radiation would tend to increase it.

Taking the case of a high-economy engine using 11 pounds of steam per indicated horsepower at 175.3 pounds gage pressure and exhausting into a condenser at 28 inches vacuum, and applying the same method as before, the total heat equals

$$11 \times 1197 = 13{,}167$$

B.t.u. The heat left in the exhaust equals

$$13{,}167 - 2542 = 10{,}625$$

B.t.u. The heat corresponding to saturated steam at condenser pressure equals

$$11 \times 1112.4 = 12{,}236$$

B.t.u. The error amounts to

$$\frac{12{,}236 - 10{,}625}{12{,}236} = 0.132,$$

or 13.2 per cent.

By using higher economies and lower condenser pressures the figure reaches above 15 per cent., as can be seen by working out the necessary example. This error is too large to be neglected in scientific investigation, and a rational formula should take this into account.

I also take a different view of expressing the ratio of heating surface of the boiler to the cooling surface of the condenser. I think Professor Thurston was the first to express this ratio, but the idea is entirely too crude and unscientific to be propagated.

The methods of computing the total heat as illustrated may be objectionable to some, on account of the uncertainty in the data on the transmission of heat through the plates. The experiments usually quoted are those of Joule and Isherwood. However, they are far from the actual conditions that exist in a condenser. The rapidity of the cooling water passing through the tubes affects the rate of absorption; the higher the velocity the higher the absorption.

To my mind the rational formula should be based on actual conditions, theoretically correct, and then multiplied by a factor expressing the efficiency as a cooler.

Alphonse A. Adler.

Brooklyn, N. Y.

Method of Setting Gas Engine Valves

Nearly all directions for setting valves give certain crank angles at which the valves should open or close. The cams having fixed contours allows of adjustments only by varying the relative lead or lag, and the amount of clearance or lost motion in the connections. It follows, then, that with a certain clearance the closing of a valve becomes fixed as soon as the opening is fixed, or *vice versa*. Too much clearance not being desirable, it is limited to a small amount, and the smaller the more limited is the adjustment.

The placing of the flywheel at definite crank angles requires measuring off angles, or the use of trams, when points have already been marked on the wheel. Why not give definite piston positions and set the valves when the piston is at those positions? Marks may be made on the guides at the right places, or measurements may be taken from the points of extreme travel. Thus the inlet should close when the piston has started back a certain distance, and the exhaust should open when the piston is at a certain distance from the end of its stroke. With the piston placed at a given position the inlet valve is set too close. It will open at the right place if the clearance is set right. With the piston at another position, in the proper stroke, the exhaust valve is set to open and will close at the correct time with the clearance set right.

F. W. Hollman.

Baltimore, Md.

What Knocked the Cylinder Head Out?

Some time ago both cylinder heads of an Atlas automatic cutoff engine were knocked out, the wrist strap pulled apart and the connecting rod badly bent.

The piston was fitted with rings, made in three sections with a lap joint and a brass bushing and a coiled spring under each joint. One of the sections began to rattle one day and an examination showed that the rivets had worked loose. We repaired them and replaced the rings.

As the engineer was putting the piston in place the "boss" came around and, noticing the way he was placing the rings, told him they were wrong, stating that the bushings and springs should be in the center of each section instead of at the joint. As one-half of the outer rings travel over the counterbore in this type of engine, it may account for the trouble.

The bushing being in the center of each section may have allowed the sections to rock, thus letting one end of a section extend out far enough to catch in the counterbore, when the velocity of the flywheel pulled the wrist strap apart, carrying the crank and connecting rod around, the connecting rod striking the crosshead, knocking it through the crank-end cylinder head and the piston out through the head-end cylinder head.

W. A. Hamlin.

Paola, Kan.

Firemen's Conditions Should Be Improved

While the many developments in boilers, engines and their accessories have placed greater responsibility on engineers, there has been, to a great extent, corresponding improvement in the status of the engineers themselves.

Passing over the question of salaries, the average engineer nowadays has privileges, and his comfort and convenience are consulted to an extent unthought of in the old times. These things had to come and will continue to come in the natural evolution of events.

But what of the fireman? Happening in a boiler room recently, just as watches were being changed, the engineer made the remark to me that "there are two dandy firemen." Yet as we talked these firemen were washing in a greasy pail, and their street clothes hung, exposed to ashes and dirt, on the bare wall.

In another plant, wagons deliver fuel directly from a driveway, along the whole front of the boiler room, which is practically wide open all the time. The fuel is dumped on the floor along the boiler fronts, leaving but a small space for the firemen to stand in while at work.

What, then, of the average stationary fireman? Is his life made any easier, does he get any more thought from employers than he did twenty years ago?

W. Auld.

Milwaukee, Wis.

An Unusual Crank Shaft Repair

The engine on which the herein described repair was made is a 600-horsepower, 18 and 36 by 36-inch, cross-compound condensing engine, side crank on the high-pressure side and center crank on the low-pressure side, direct-connected to an 8-inch line shaft on the low-pressure side. The rather unusual design of this engine, the first of its type put out by the builders, made it a subject of much interest and attention. It was prophesied that it would run warm on the low-pressure side, but the engine was on duty 150 continuous hours per week for more than a year, and after the first night evidenced no cause for uneasiness, running but a trifle warm after this hard service.

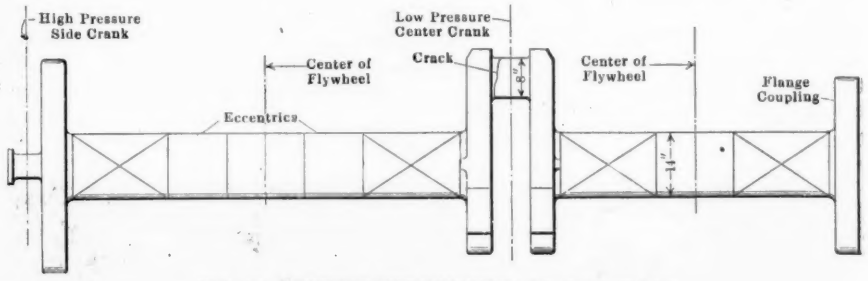


FIG. 1. SHOWING THE LOCATION OF THE CRACK

Needless to say, then, that after a little over a year's time the superintendent was astonished to find, upon taking out the center-crank connecting-rod brasses for examination, a small and almost imperceptible crack on the surface of the center-crank pin, running about ⅝ of the way around the pin, as shown in Fig. 1. The extent of this crack, after being drilled in for ½ inch or so, and examined by representatives of both the builders and the plant, was still only a matter of conjecture. The question to be solved was how to make the repair with the least possible interruption to service, and at the same time at a cost which should not be prohibitive. A new crank shaft being out of the question, and those in charge not knowing sufficiently well the staying qualities of thermit welding, it was decided to adopt the following method, which proved entirely satisfactory:

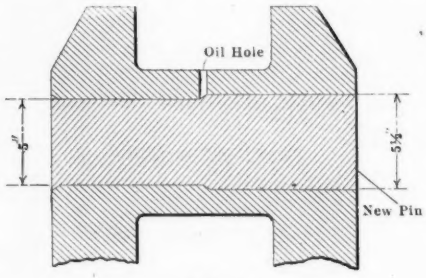


FIG. 2

The pin was drilled through as shown by Fig. 2, leaving the original pin as a shell. The bore was made 5½ inches on one end and 5 inches on the other, thus leaving a ¼-inch shoulder, so that when the pin was drawn in against the shoulder, the small end could be riveted into the countersink, flush with the cheek of the crank, thus preventing side motion on the part of the pin, and at the same time serving to draw the crack together. The shoulder was made to come midway the length of the pin, so that the confined air would not cushion against the shoulder, but would escape through the original oil hole. It was a drive fit, the crank cheeks being warmed and the pin pulled in with a stud at the small end and driven in at the large end at the same time.

The method of boring out is also of interest. A timber superstructure was built up above the crank shaft, the ends being supported by the flywheel on either side and an old lathe head, rigged up with a self-feed, was inverted and bolted to the timber work. The distance between the crank cheek and flywheel did not permit the headstock being set upright in the usual position, as the feed works interfered with the hub of the flywheel, hence the necessity of inverting it.

The first drill was made with an 1¼-inch twist drill and after being redrilled to 2½ inches a regular boring bar was used in the usual manner. A small 1½-horsepower vertical engine was used to drive the lathe head. More than six months have passed and everything seems to indicate the entire success of the repair.

L. C. Blake.

St. Louis, Mo.

The fourteenth entertainment and ball of the Eccentric Firemen's local union No. 56, I. B. of S. F., of New York City, will be held at the Grand Central Palace, Saturday evening, January 23. Aside from the entertainment program, as usually provided by the best professional talent, there will be a special four-hand reel exhibition and exhibition drill by the Eccentric Firemen's Fife and Drum Corps. The proceeds of the occasion will be turned into the death-burial fund.

Transmission of Power by Leather Belting*

A Diagram Giving, without Calculation, the Size, Speed, Capacity, etc., of Belts, Including Effects of Slip and Centrifugal Force

BY CARL G. BARTH

The common assumption that the sum of the tensions on the tight and slack sides of a belt remains constant was shown to be a fallacy by Wilfred Lewis in 1886.** The coefficient of friction between the belt and the pulley varies greatly with the velocity of slip, and the centrifugal force of the belt has a great deal of effect. The accurate calculation of the size or capacity of a belt is, therefore, a much more complicated matter than the allowance of so many feet per minute of belt to the horsepower, even when the latter calculation is modified to allow for angle of contact.

Mr. Barth has evolved formulas covering all of the variables and enabling him to construct the diagram shown on pages 170 and 171, the nature and use of which can best be described and illustrated by working out a couple of examples.

EXAMPLE 1: The maximum cone step on the countershaft of a lathe is 22 inches in diameter and wide enough to carry a 3-inch double belt. The speed of the shaft is to be 300 revolutions per minute. Assuming the thickness of a 3-inch double belt to be $\frac{5}{16}$ of an inch, and the arc of contact of the belt to be 170 degrees: (a) What pull can the belt be counted on to exert, and what horsepower will it transmit with this pull? (b) Under what initial tension will the belt first be put up, and retightened from time to time? (c) And what minimum initial tension must it not be allowed to fall below to insure the above-determined pull without undue slip?

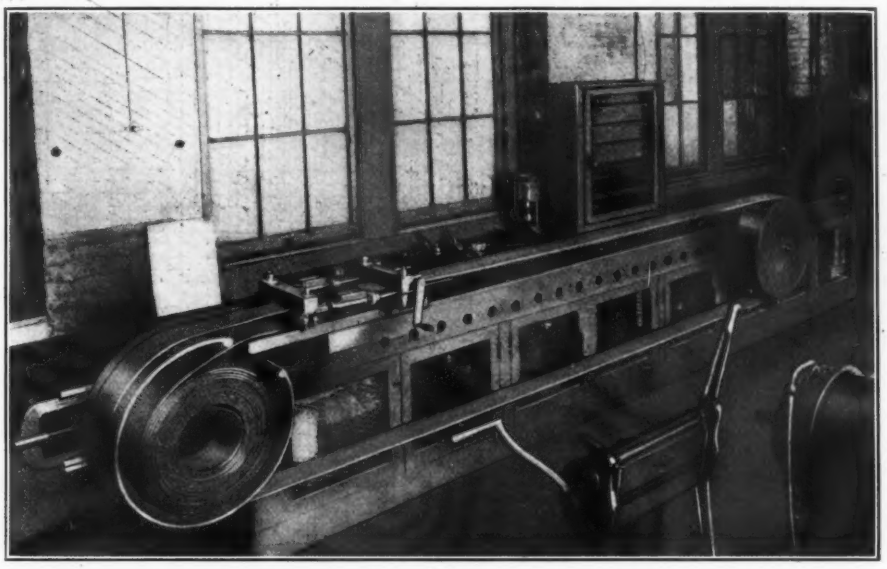


FIG. 1. BELT-BENCH IN THE SHOPS OF THE LINK BELT COMPANY, NICETOWN, PHILADELPHIA. THE USE OF THE BELT-SCALES IS SHOWN IN DETERMINING THE LENGTH OF A NEW BELT

Solution: To get the answer to question (a), we first turn to the small bottom portion of the diagram plate, and on its right-hand side note the point reading 300 revolutions per minute. From this we pass horizontally to the left until we intersect the vertical line from the point reading 22 inches on the scale of pulley diameters at the bottom line of the diagram. From the point of intersection we follow the diagonal line upward to the bottom line of the main portion of the diagram, and there read the velocity of the belt to be about 1700 feet per minute. The points of intersection referred to have been indicated upon the diagram by small circles.

We now note the point that corresponds to this belt speed of 1700 feet per minute in that scale on this same bottom line of the main diagram which is marked "Velocity for Pull of Machine Belt" and interpolate a vertical line extending upward from this point. (The circle between 1300 feet and 2000 feet, about the middle of the left-hand diagram is at the bottom of this line.) Then leaving this for the time being, we turn to the extreme left-hand portion of the diagram and there note the point corresponding to

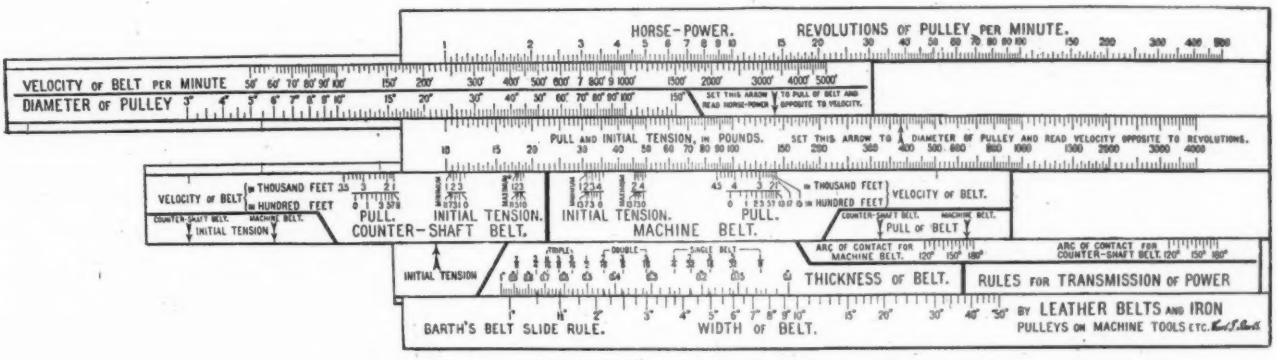


FIG. 2. SLIDE RULE FOR THE MORE CONVENIENT SOLUTION OF BELT PROBLEMS SOLVED BY THE DIAGRAM

**Proc., A. S. M. E., Vol. VII, p. 549.

*Abstract of paper presented at the monthly meeting, January 12, of the American Society of Mechanical Engineers.

vertical line marked 140 degrees and then the new diagonal until it intersects the vertical marked 170 degrees at the top of the diagram, in the field marked "Arc of Contact," and then continue horizontally until we intersect the interpolated vertical line for the belt speed 1700 feet already noted.

From the point of intersection we follow the diagonal upward and to the right until we meet the vertical scale of pounds, on which we now read the belt pull to be 140 pounds; and continuing horizontally until we meet the vertical line extending upward from the point corresponding to the belt speed originally found on the scale of belt speeds in this section of the diagram, and from this line diagonally to the vertical scale of horsepower, we read off the horsepower transmitted to be 7.2.

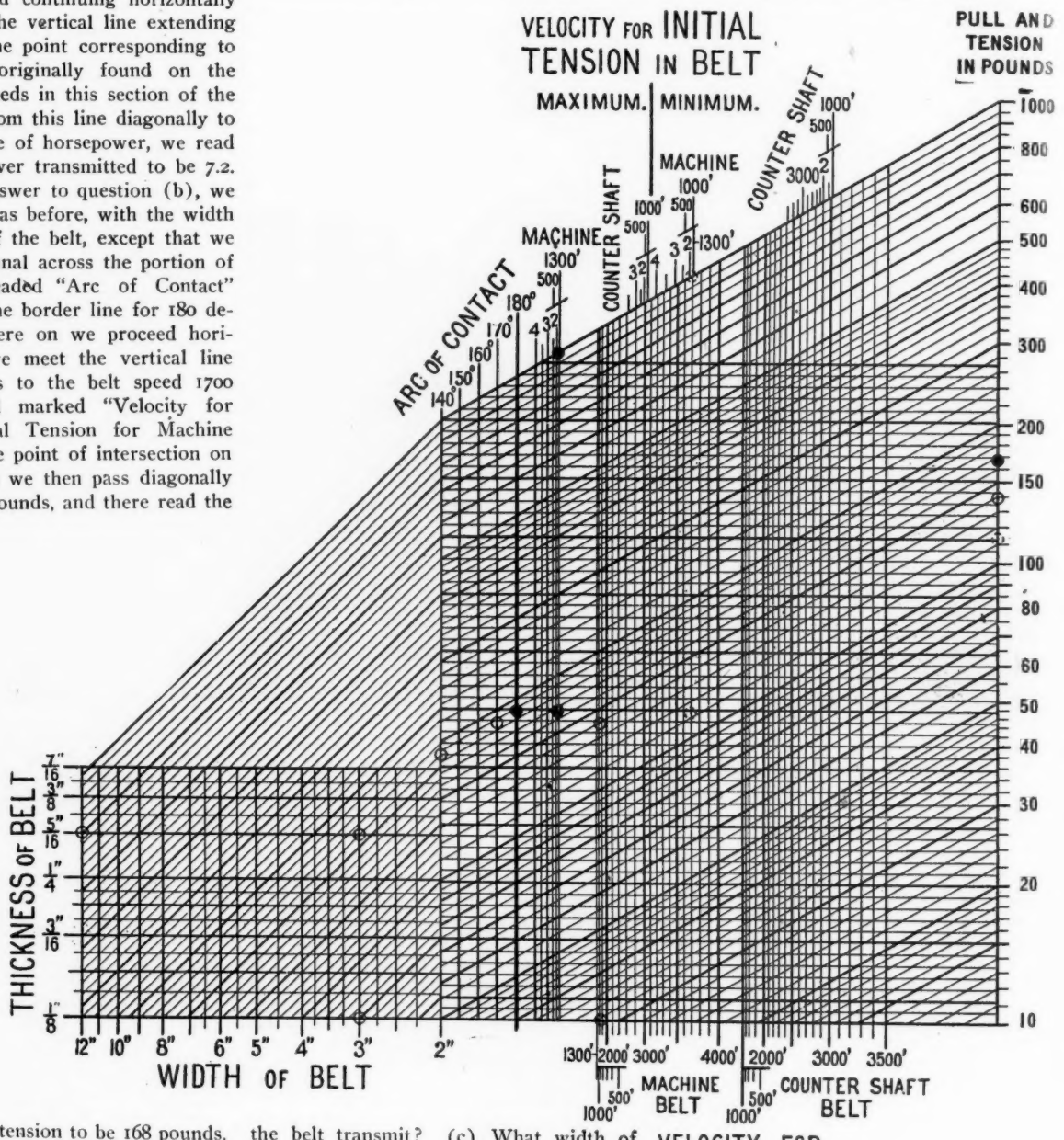
To get the answer to question (b), we proceed exactly as before, with the width and thickness of the belt, except that we follow the diagonal across the portion of the diagram headed "Arc of Contact" until we meet the border line for 180 degrees. From here on we proceed horizontally until we meet the vertical line that corresponds to the belt speed 1700 feet in the field marked "Velocity for Maximum Initial Tension for Machine Belt." From the point of intersection on this vertical line we then pass diagonally to the scale of pounds, and there read the maximum initial tension to be 168 pounds. Those movements for this solution on the diagram that differ from those for the answer to question (a) are indicated by little filled-in circles around the various points of intersection noted.

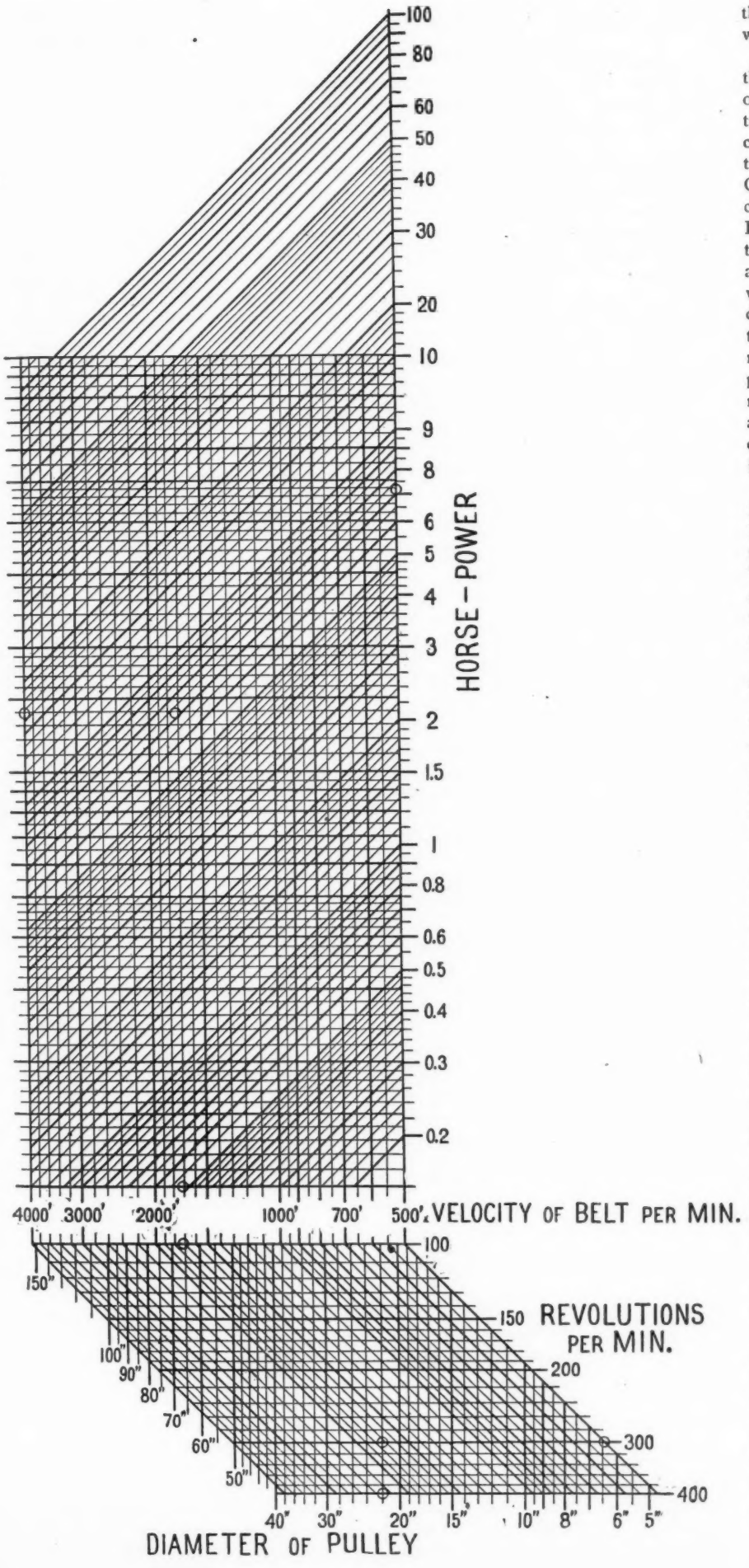
For the answer to question (c), we proceed in every respect as we did for question (b), except that we, of course, proceed from the point corresponding to the belt speed 1700 feet in that field of the scale on the top line of the diagram which is marked "Velocity for Minimum Initial Tension for Machine Belt." The answer read off on the vertical scale of pounds is 113 pounds. The movements for this solution on the diagram that differ from those for the answer to question (b) are indicated by little dotted circles around the points of intersection.

EXAMPLE 2: The countershaft in Example 1 is to be driven by a belt to run at a speed of 3000 feet per minute. (a) What diameter of pulley is required to give this belt speed? (b) What pull must the belt transmit? (c) What width of double belt must be used? (d) And what will be the initial tension under which the belt must be put up, and to which it must be again retightened after falling to the minimum? (e) What will be its minimum tension?

Solution: (a) As the countershaft is to make 300 revolutions and the belt is to run at 3000 feet per minute, we turn to the small diagram at the right-hand bottom corner of the main diagram, proceed horizontally to the left from the point marked 300 on the scale of revolutions on the right, until we meet the diagonal line from the point marked 3000 on the horizontal scale of velocities. From the point of intersection we then go vertically down to the scale of pulley diameters, and there read off 38 inches as the nearest even diameter.

(b) To get the pull of the belt we remember that the cone belt was found in Example 1 to transmit 7.2 horsepower. We therefore note that point on the vertical scale of horsepowers at the extreme right of the main diagram which corresponds to 7.2, and then follow the diagonal from this point toward the left, until we meet the vertical line extending up from the point marked 3000 on the scale of velocities on the bottom line of this portion of the diagram. From this point of intersection we continue horizontally to





the left to the vertical scale of pounds, on which we then read off the pull 80 pounds.

(c) From the point corresponding to these 80 pounds we now continue diagonally to the left until we meet the vertical line extending up from the point corresponding to the belt speed 3000 on the scale marked "Velocity for Pull of Countershaft Belt" at the bottom of this central portion of the main diagram. From this point we continue horizontally to the vertical line corresponding to the arc of contact, which, not being given, we will assume as 160 degrees, and then again diagonally in the extreme left-hand section of the diagram. Any simultaneous readings of width and thickness from points in the diagonal along which we are now moving, will then give a proper belt, and assuming as in Example 1 a thickness of $\frac{5}{16}$ inch, we find the width to be 3½ inches.

(d) To find maximum initial tension for this belt, we proceed exactly as in Example 1, except that we use the scale marked "Velocity for Maximum Initial Tension for Countershaft Belt" at the top of the middle section of the diagram, and then read this off on the scale of pounds as 157 pounds.

(e) Similarly, we find the minimum initial tension to be 97.5 pounds.

In his paper, "Notes on Belting,"* F. W. Taylor referred to belt clamps provided with spring balances for weighing the tension in a belt. In the case of endless belts these scales are put directly on a belt in its final position over its pulleys, while in the case of a belt with wire lacing, this is cut to length under the required tension on the specially designed belt bench illustrated in Fig. 1. As will be seen, this bench is provided with a pair of pulleys which can be so adjusted that a tapeline will measure the same around these pulleys as over the pulleys on which the belt is to run. A belt cut and laced to give a certain tension when the bench pulleys have been properly adjusted, will then be of a length to assume the same tension over its own pulleys.

This indirect way of securing a desired tension in a belt was first suggested by our fellow member, Gullow Gulowsen, who also made the drawings from which the first bench and the first improved belt scale were made by the Bethlehem Steel Company in the year 1900.

To sum up, the writer's work on the subject has mainly consisted of the following:

(a) To establish a mathematical formula for the relation between the tension in a belt and the stretch due to this tension, based on experiments made at different times by Wilfred Lewis, Prof. W. W. Bird and himself.

(b) By means of the knowledge of the elastic properties of leather belting expressed by this formula to develop a for-

*Proc. A. S. M. E., Vol. XV, p. 204.

mula for the relations between the tensions in the two strands of a belt-transmitting power, which formula takes account of the influence of the sag in a horizontal belt, and agrees substantially with the results of the experiments made by Mr. Lewis, when plotted in the manner first done by Professor Aldrich.

(c) To establish a formula to express the relation between the coefficient of friction between a belt and a cast-iron pulley, and the velocity with which the belt slips or slides over the pulley, as revealed by plotting the results likewise obtained by Mr. Lewis.

(d) The construction of a diagram embodying the formula expressing the relation between the two tensions in a belt, the well-known formula for the loss in effective tension due to centrifugal force, and the likewise well-known formula for the ratio between the effective parts of the two tensions, as determined by the coefficient of friction and the arc of contact of the belt on its pulleys. These formulas are so correlated on the diagram that problems dealing with the contained variables may be solved graphically, while a direct algebraic solution is possible only for a vertical belt, or what is the same thing, by neglecting the effect of the sag of a horizontal belt. A plate containing this diagram accompanies Mr. Barth's paper.

(e) Also by means of the better knowledge gained of the elastic properties of leather belting, to develop a formula for the creep of a belt on its pulley due to the difference in the tensions in the two strands, along the lines outlined by Professor Bird in his paper on "Belt Creep," read at the Scranton meeting in 1905.

(f) The construction of diagrams showthe pulling power and other relations of the two tensions of a belt of 1 square inch cross section and 180 degrees arc of contact at different speeds, under certain conditions and assumptions recommended by the writer. Also a modification of these diagrams for extended practical use, on which may be read off: (1) The pulling power of a belt of any width and thickness and any arc of contact, between 140 and 180 degrees; (2) the initial tensions below which the belt must not be allowed to fall in order to confine the slip and the consequent loss of efficiency of transmission within certain limits; (3) the initial tension to which it is recommended that the belt be retightened after falling to this minimum limit. (Plate 2 of the paper, reproduced herewith.)

(g) Finally, the construction of a slide rule serving the same purpose as the diagram just mentioned, but which is much handier than the diagram. See Fig. 2.

An exchange states that sileo-vanadium steel is now used in making transformers, as on account of its improved magnetic quantity it decreases the core loss.

The Effect of Steam Jacketing

To the Editors:

I inclose a copy of a letter written to Bryan Donkin, of London, with whom I had numerous interviews when he was upon the Continent.

This letter is interesting from the theories which are there brought out and which have since been recognized as correct and largely applied.

H. Bollinckx.

Brussels.

M. Bollinckx' Letter to Mr. Donkin

I am in receipt of your kind letter of the second instant, and have just finished reading the pamphlets which you inclose.

I conclude, firstly, that the marine machines are not very economical, as I have always thought, and of which I have had proof in my own country in a compound vertical machine of 500 horsepower consuming nearly 10 kilograms (22 pounds) of steam per horsepower-hour.

All that you say in your paper is perfectly correct according to my idea, and it is by following these ideas that I have constructed my engines for a long time:

(1) The admission of the steam at the top of the jacket in order that the water shall be thrown to the bottom of the jacket and that the cylinder shall be freed from drops of water.

(2) Surfaces carefully polished in order to diminish initial condensation.

(3) The smallest amount of surface possible in the presence of the entering steam, and these surfaces well polished as above stated.

(4) To diminish, if possible, the clearance space; but I attach less importance to this last point.

As I have written you before, I try to make my cylinders as thin as possible, and it is for this reason that I use the heavy reinforcing rings in order to give them the necessary strength. I am going to use the same thing for the heads of my cylinders, and even for the pistons. I am going to heat the pistons, as M. Berger-André, of Thann, has done, as the reason that I have for heating the cylinder wall is the same as that for heating the piston, and it is only the difficulty of heating the latter which has delayed my doing it up to the present. But within the last six months I have been able to obtain tubes strong enough so that I could make a hollow piston rod by which I will introduce the steam, and into which will pass a second tube for taking out the water of condensation. M. Berger-André has obtained in this way an economy of 5 per cent., but the difficulties of construction and of maintenance led him to abandon the idea.

I have read with much interest the account of your tests on the Sulzer engine, in which you introduce the steam during the compression and before the admission. I am astonished that this filling up did not cause the pressure to mount higher in the clearance space, which goes to prove the enormous amount of condensation which is taking place in that space at the moment of the injection of the steam; and certainly if the surfaces are not of a certain temperature one will never obtain a certain pressure by compression in that space.

I come now to the tests in which the jacket was heated by steam having a higher pressure than that which was used in the cylinder. I have read a great many reports of tests made upon this subject, and yours interest me the more because you have approached the subject with so much care. The economy is low, but I should certainly have said that it would have been more considerable. I do not know to what to attribute this effect. I have already investigated the subject of the tests on the compound engines constructed by my competitors and myself, but they have only resulted in confusing my ideas, for I have constructed compound machines (and they also) where the jacket of the larger cylinder and the receiver were heated with steam at six atmospheres and the efficiency remains the same as that of machines in which the receiver is not provided with a reheater and in which the jacket of the low-pressure cylinder is heated simply with the charge coming from the high-pressure; that is to say, with the same steam which operates in the low-pressure cylinder itself. It may be that when the jacket is heated by steam of a greater pressure than that which is used in the cylinder, there is practically no circulation and that the water deposited about the cylinder, the film of water, as you say, hinders the transmission of heat. I do not know anything about it, but the fact is there.

I know also of the tests with superheated steam, and Schaerer sent me an apparatus four months ago, but it is not yet in place so that I cannot make tests upon my engine. The superheated steam will, of course, give less advantage when one has a good boiler which furnishes dry steam and a good compound engine which does not consume more than 5.7 kilograms (12.5 pounds) of steam per indicated horsepower like ours.

One thing which astonishes me also is that engines where the steam coming from the boiler circulates in the jacket before entering the cylinder do not give a greater economy when the passages (the entrances for the steam to the valve) are so small as to produce a fall in pressure of one or two atmospheres. In effect, this constitutes a jacket operating at a pressure higher than that of the steam in the cylinder, and the steam itself is somewhat superheated, owing to its sudden loss of pressure.

Hirn and Hallouer pretend to have obtained good results in this way and concluded even that expansion is unnecessary to the economical use of steam and that

throttle governing is quite sufficient. Is this your own opinion?

Jackets heated by means of oil must operate poorly, as the conducting power of the oil is not good. I believe that a very thin jacket could be made to give good results, and I believe that if the cylinder barrel is well provided with fins it will transmit heat still more quickly,

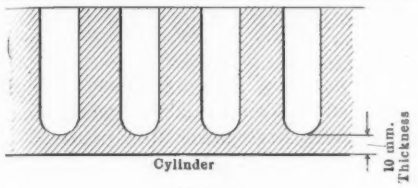


FIG. 1

and that the difference in temperature between the metal interior of the cylinder and the steam will be reduced. If you reduce this difference you reduce also the initial condensation. Is this your idea?

I have also experimented (but the engine, I believe, was not well run during the test) with an apparatus in the receiver for separating from the steam coming from the high-pressure cylinder on its way to work in the low-pressure all the water which it contains.

I always use a separator upon the high-pressure cylinder, and I believe that if the water can be separated from the steam before it enters the low-pressure cylinder, it would do a great deal of good.

H. BOLLINCKX.

[M. Bollinckx' letter is accompanied by blueprints reproduced herewith, showing

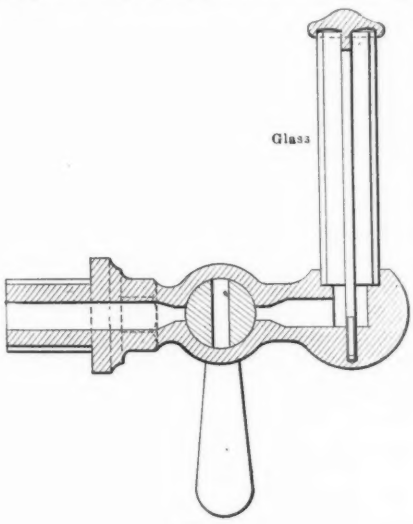


FIG. 2

in Fig. 1 the grooved exterior wall of the cylinder, and in Fig. 2 an indicator for showing the action of the steam. At the period of admission the steam in the glass is foggy. It clears up somewhat during expansion by reëvaporation, and the instant the exhaust valve opens it becomes clear, showing the formation by reëvaporation of steam which goes to the condenser. Donkin invented such an instrument, but that here shown is claimed by M. Bollinckx to have been invented independently by himself.—EDITORS.]

Alcohol versus Gasolene for Internal Combustion Engines

BY JAMES E. STEELY

There has been considerable comment on the possibilities of denatured alcohol as a substitute for gasolene in internal-combustion engines. A close analysis of the relative merits of the two fuels brings out some facts which are not generally known, and which are of interest to both the engine operator and the designer.

Gasolene consists principally of a mixture of pentane and hexane. The heat value of these compounds is about 21,000 B.t.u. per pound, while that of alcohol is but 13,700 B.t.u. per pound. However, there is a compensating factor which eliminates most of this difference. The reaction which expresses the explosion of gasolene vapor is as follows:

Gasolene Vapor. Air.

$$2\,C_6H_{14} + 19\,O_2 + 76\,N_2 =$$
$$12\,CO_2 + 14\,H_2O_2 + 76\,N$$

2 vols. + 19 vols. + 76 vols. =
12 vols. + 14 vols. + 76 vols.

Hence, 97 volumes of explosive mixture produce 102 volumes of "burned" gases, there being a certain increase of volume due to the increase in the number of gas molecules. Thus, if 1 cubic foot of the mixture were exploded, 1.0515 cubic feet of gaseous products would be formed even if no heat of combustion were given off. The specific heat of the resulting gases would be about 0.18387 at constant volume. Since 1 pound of pentane requires 15.9 pounds of air, there would result 16.9 pounds of spent gases; 3.10 B.t.u. would be required to raise the temperature of this weight of gas 1 degree Fahrenheit. Taking the heat value of gasolene as 21,000 B.t.u. per pound, the rise in the temperature of the exploded gases would be 6759 degrees, theoretically.

Following the same line of reasoning for alcohol under the same conditions will give results which show the relative values of the two fuels. The equation for the combustion of alcohol vapor is as follows:

Alcohol Vapor. Air.

$$C_6H_6O + 7\,O_2 + 28\,N_2 =$$
$$6\,CO_2 + 3\,H_2O + 28\,N_2$$

1 vol. + 7 vols. + 28 vols. =
6 vols. + 3 vols. + 28 vols.,

or 36 volumes of mixture produce 37 volumes of spent gases. There is, therefore, an increase in volume due to the increase of gaseous molecules, but this increase is not as great as with gaseous vapor. One cubic foot of the original alcohol mixture makes 1.0278 cubic feet of spent gases. The specific heat of the exhaust gases at constant volume is 0.17668. One pound of alcohol requires 10.72 pounds of air making 11.72 pounds of gas, which requires 2.07 B.t.u. per pound to raise the temperature 1 degree Fahrenheit. The temperature would be raised theoretically 6618 degrees, which is more than 100 degrees less than that computed for the gasolene mixture.

OTHER INTERESTING FACTS

A close study of these reactions brings out some other interesting facts. For example, one volume of gasolene vapor requires about 50 per cent. more air than the same volume of alcohol vapor. On referring to the formula it will be evident that each alcohol molecule contains oxygen, and therefore does not require as much oxygen for combustion as a hydrocarbon molecule. However, this oxygen contained in the molecule greatly facilitates the combustion. Everyone knows that alcohol will burn without smoke, while gasolene always makes smoke unless it is first vaporized and then mixed with sufficient air. It is probable that there would be less trouble from cylinder deposits of soot with alcohol than with gasolene.

As to mixing of the charge, there is little advantage for either fuel. If anything, the alcohol vapor is slightly heavier than the gasolene vapor; therefore the latter will diffuse somewhat more rapidly.

The foregoing facts indicate that gasolene is superior to alcohol in nearly every way. The volumetric increase of the former is over 2 per cent. greater and the theoretical temperature of explosion is 140 degrees higher; consequently, the initial pressure of the exploded gasolene mixture will be greater than that of the alcohol mixture. Tests have probably been made and will be made which show that alcohol is as good as gasolene, or even better, but the blame should be put on the carbureter or the mixture rather than on the fuel. A few years ago when the industrial alcohol craze struck this country people expected too much from this fuel because of the ease with which it could be manufactured and the variety of products from which it could be made. In spite of the fact that the revenue has been removed from industrial alcohol for over two years, the price is still too high to consider it as a fuel on any practical scale. With alcohol at the same price as gasolene, there would still be a difference in favor of gasolene.

Another feature which should not be overlooked is the ease with which alcohol can be diluted with water. Unless the alcohol were bought from a reliable dealer, it would have to be tested before use or it might cause no end of those "mysterious" gas-engine troubles. Gasolene can be diluted only with a hydrocarbon, such as kerosene, and while it may not vaporize as readily, yet the kerosene will develop power when ignited in the cylinder.

With alcohol as high in price as it is and gasolene as low as it is, the proper direction for investigation is along the line of the better combustion of gasolene or other hydrocarbon mixtures.

POWER AND THE ENGINEER

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The Line "Recognizes" the Staff

The engineer, realizing his absolute responsibility for the ability of the vessel to move, has been accustomed to shrug his shoulders in the inconspicuous background while press and public and officialdom lauded and feted the captain of a vessel which had made an exceptional run. "Fighting Bob" Evans modestly brushes this credit aside. "I am not the one man who took the fleet to San Francisco," says he. "The man who brought the fleet around the Horn is the man who boiled the water in the fireroom and the man who peeled the potatoes. They have done as much to take it, step by step, as the keen-eyed officer on the deck or the gray-haired captain on the bridge."

The pendulum may hit the engineer in swinging back.

Hackneyed Contributions

There are some engineering subjects which, like the poor, will always be with us; such as how to keep the ashpit clean, methods of firing practiced fifty years ago, necessity of keeping the water level at the second gage, objections for and against valves in the water-column connections, loss of boiler economy for each one-sixteenth inch of scale, whether the pressure should be on the stem or disk side of a globe valve, and whether a belt should be run hair or flesh side to the pulley.

Superheated steam has been a live topic for discussion, and many articles have been written by those who did and did not know what they were talking about; but with the passing of the years, many of the old notions regarding the use of superheated steam have been dispelled, especially regarding its effect upon packing, cylinder lubrication and the operation of valves other than those of the poppet type. Not many years ago, a member of a certain engineering society had under way the preparation of a paper, to be read at the next meeting of the society, regarding the difficulties encountered in using superheated steam, and especially dealing with its nonuse in the ordinary type of steam engine. Doubtless the paper would have been read before an intelligent body of men as planned had it not been pointed out that the difficulties which were singled out as restricting the use of superheated steam had been so overcome that they were not classed as difficulties, any more than any other feature in steam-plant operation.

In posing before the public as an authority the individual should know that his position is unassailable. If a writer makes an erroneous statement it will be strange if someone does not bring the matter to his attention. The one who is mistaken in his beliefs may have some excuse, and the one who does not know may learn through the school of criticism. Both of these kinds of writers are being constantly met with by the editorial force of this paper, and they are dealt with courteously and a helping hand is given when required.

The Future Large Gas Engine

Reciprocating steam engines for land service are built up to about twelve thousand brake horsepower and turbines up to fourteen thousand kilowatts, or about twenty thousand brake horsepower per unit. Twin-tandem gas engines have been built in this country up to five thousand four hundred brake horsepower, or one thousand three hundred and fifty horsepower per cylinder, using a rich gas; with less "snappy" gas the same engine could doubtless be worked up to fourteen or fifteen hundred horsepower per cylinder by building it with higher compression. These figures mean, obviously, that the gas engine of the future for large power-plant service must be built in much larger units than the present knowledge of design permits, if it is to compete with steam. Urban central stations cannot afford to provide one and a quarter square feet of generating room ground plan for each brake horsepower of output, which is about the size of the huge Gary plant. Nor is it usually profitable to divide the total output of even a big station into twenty or more units.

The greatest internal cylinder diameter thus far employed in this country is forty-four inches; somewhat larger cylinders are in successful service abroad, but the difference is not important from the viewpoint under discussion. To develop ten thousand brake horsepower at eighty-five per cent. mechanical efficiency a twin tandem four-stroke engine would need cylinders not less than eighty inches in diameter, which is far beyond any recorded size ever built.

The chief difficulty in the way of building large engines is the enormous quantities of heat to be got out of the cylinder per cycle, which difficulty is augmented by the well known decrease in the ratio of wall surface to volumetric capacity with increasing diameters. Consideration of this feature of the problem alone would lead straight away from the accepted "ideal" of a hemispherical combustion chamber and in the direction of a flattened extension of the cylinder proper, but only actual experiment can determine how far one could go in that direction without developing other difficulties of a more or less prohibitive nature.

Whatever may be the method of doing it, however, it is quite evident that the construction of much larger units than have yet been produced must be made practicable if the gas engine is to gain

the standing in large power-plant work that its rapid improvement in operating characteristics bids fair to justify.

Boiler Plant Capacity

The average plant consisting of several boilers is laid out to operate on one stack, and this stack is generally proportioned properly to serve the boilers installed. It often happens that the original capacity is soon outgrown and the need of additional boilers is felt, and these are installed and connected to the stack without any thought being given to the question of whether the stack is of sufficient capacity properly to care for the added boilers.

It sometimes transpires, too, that, owing to several such additions of boilers, the overloading of the stack becomes so pronounced that further additions to the boiler equipment tend to reduce the capacity of the plant as a whole rather than to increase it.

It should be the duty of every progressive engineer to know at what points the capacity of his plant will be reached first, so that when the call for additional power comes he will be ready to suggest how his employer's money can be most advantageously spent to obtain the desired increase in capacity.

In a boiler plant there are three main features of general design that limit the capacity, and each of these is of practically equal importance, although this does not seem to be generally appreciated. The first, and the one which is often assumed to be the all determining factor, is the actual boiler capacity, or extent of heating surface. The second is the grate capacity or area; this is fairly well taken care of as a general thing, on account of additional grate surface being always installed with each addition to the boiler capacity. Thirdly, is the draft capacity, and this is liable to be anything in a plant that has been through several changes. It must be remembered that draft capacity does not mean simply a chimney capable of furnishing a given volume of air, but also that the gas passages from the grate to chimney are of ample proportions and proper shape; also, that the draft be of the correct intensity or sharpness to suit the quality of fuel used. Some of the lower grades of fuel are only burned successfully with artificial draft. The quality of the fuel also affects the grate area required.

If your boiler plant is showing signs of overload, determine individually if the heating surface, grate area and draft are properly related when the class of fuel used is considered, so that they may work in unison to produce the highest plant capacity. This correct proportioning of the several capacities will tend toward the economical generation of steam. Remember that all any boiler can do is to absorb a certain portion of the heat generated on the grate and to generate the full amount of heat that a given boiler is capable of absorbing efficiently, requires the correct grate and draft capacity for the particular kind of fuel used.

A Remarkable Statement

On January 4 the Supreme Court of the United States reversed the decision of the United States Circuit Court declaring the eighty-cent gas law confiscatory. In announcing the decision of the court, Judge Rufus W. Peckham made public an abstract of the opinion in which the following statement was made:

"The proof unquestionably shows great possible if not probable danger of explosion in the mains or other pipes if the pressure demanded were applied to them as they now are."

The State law in question required that gas of at least twenty-two candle power should be supplied at a pressure not exceeding two and one-half inches of water. It surely cannot be this pressure to which the court refers, as the stress set up in the walls of a twelve-inch cast-iron pipe three-fourths inch thick by this pressure would be too small to be measured. But what else can the decision refer to and why should that portion of the law be declared null and void? Illuminating gas does not explode on the application of pressure; in fact, we seem to have heard somewhere that air or rather oxygen in rather large quantities must necessarily be present along with illuminating gas in order that an explosive mixture be formed, and even then a spark or external heat is required to start the action.

It is not often that misinformation of this order appears in the decisions of our Supreme Court and it is highly probable that when the full text is made public the difficulty will have a rational explanation. However much the intricacies of the legal mind may be beyond the understanding of the average engineer, the basic principles of physics and chemistry are common property, and with the assistance of the public-school system should be possessed by every citizen.

Steam Boilers and Dynamite

Boiler explosions have occurred from many causes other than that of low water, and as plenty of these causes are natural or legitimate enough of themselves, it is not necessary for the owner to celebrate the occasion by wearing a white ribbon or for the fireman to swear that some enemy had put dynamite into the boiler. The fact should not be overlooked, however, that careless superintendence begets careless workmen, and that when handling either a steam plant or high explosives certain extra and special precautions must be taken that would not be required of a man operating a wheelbarrow. That either dynamite or a steam boiler can be used for its respective work with perfect safety is known. That both have been used in ways resulting in great destruction of life and property is also known, but to intrust the use of either to incompetent persons is dangerous.

The incident related herein about the thawing of dynamite in a boiler room may seem to engineers as a case of "served them right for doing such a crazy thing," but maybe you are doing something just as careless in your own boiler room. To those not acquainted with the habits of dynamite, it may be explained here that at temperatures below 50 degrees Fahrenheit it is in a frozen condition, and that for effective use it must be thawed out. It is this thawing operation that has given so many opportunities for carelessness and ignorance to decrease the death-benefit funds of a certain class of fraternal organizations. The dynamite cartridges are thawed properly by placing them in a watertight vessel surrounded by water which is heated to a temperature not exceeding 150 degrees Fahrenheit.

In the power plant of a certain Western mine two 60-horsepower return-tubular boilers were installed and operated at about 80 pounds pressure. One of the miners soon discovered that it was an easy matter to thaw his giant sticks by placing them on a sawdust bed on top of one of the boiler domes. Now the miner did not know that the temperature of steam at 80 pounds pressure is about 324 degrees Fahrenheit. It was not long before the bed of sawdust was scattered and the remainder became soaked with the leakage from the dynamite sticks, thus bringing the nitroglycerine in contact with the heated boiler plate. The inevitable explosion happened on schedule time, but fortunately no employee was in range of the débris. Besides the effect of the shock on the boiler setting and the general wreck of the boiler-house covering, the only damage done was to "dish in" the top and edge of the dome until it looked like a derby hat that had been struck at an angle of 45 degrees by a foul ball. That one or both of the boilers did not explode was fortunate.

Ohm's law fails when ionized gases are conducting electric current. If the distance between the terminal plates be halved, only half the number of ions will be formed and hence the current will be halved instead of doubled. Up to the point of saturation the current is directly proportional to the voltage, but above this point there is no further increase in current.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Hopkinson Flashlight Indicator

It is generally admitted that for engines running at more than 200 or 300 revolutions a minute the ordinary indicator does not give satisfactory results.

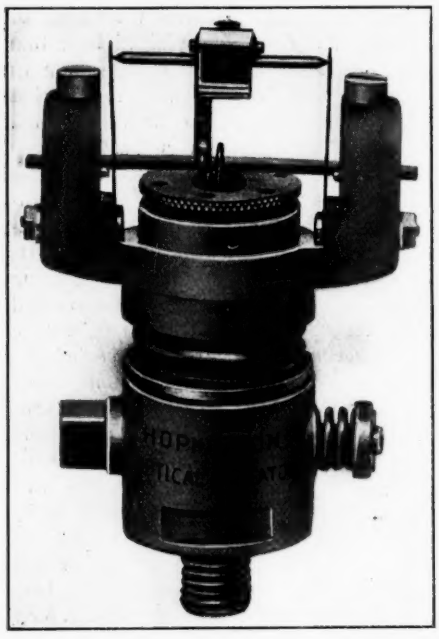


FIG. 1

The inertia of its piston and parallel motion seriously distort the diagrams, while slackness of the motion joints and friction of the pencil on the paper introduce other errors which are by no means negligible. When we come to really high speeds, such as those of petrol and other engines, the only practicable form of indicator is the optical type, in which a minute motion of a diaphragm or piston, subject to the cylinder pressure, is magnified and made visible by means of a beam of reflected light. The optical principle at once does away with inertia troubles, and when embodied in a suitable type of apparatus is capable of giving valuable results at the highest speeds at which any engine can run. Very good work has been done with such indicators, which have now been in use for some years.

In the usual form of optical indicator the pressure of the steam or gas acts underneath a metallic diaphragm, which is attached to a mirror. The deflections of the diaphragm cause the mirror to rock, so that a spot of light reflected from it traces out a line on the card. The objections to this form are twofold: Firstly, that the deflections of the diaphragm are not exactly proportional to the pressure acting upon it; and, secondly, that the heat of the steam or gas is likely to affect the calibration of the instrument by altering the elasticity of the diaphragm. To avoid any possible source of error or trouble from these causes, Prof. Bertram Hopkinson, of Cambridge University, has devised the instrument shown in Figs. 1 to 3, which is manufactured by Dobbie-McInnes, Limited, of 57 Bothwell street, Glasgow, and sold under the name of the Hopkinson Flashlight Engine Indicator.

The distinctive features of the Hopkinson indicator are shown in Figs. 2 and 3. The body of the instrument is bored to receive a piston *F*, the top of which is fitted with a wire-hook arrangement which embraces at the center a flat steel spring *D* fixed transversely above the piston. The hook does not hold the spring tightly enough to prevent the piston taking its position freely in the bore. The spring is clamped at each end to the rotating head of the instrument in the manner

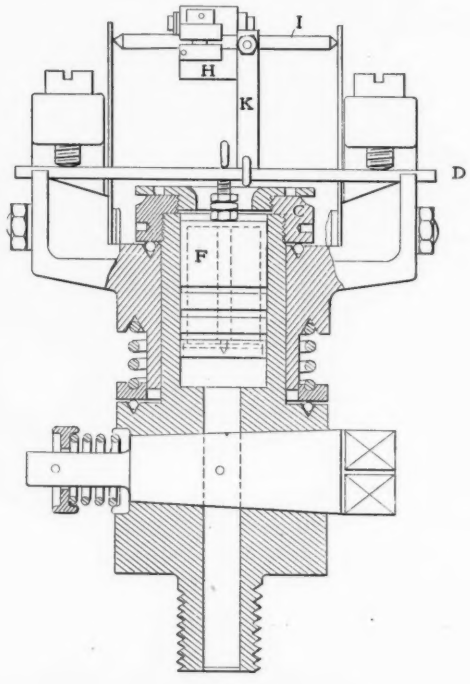


FIG. 2

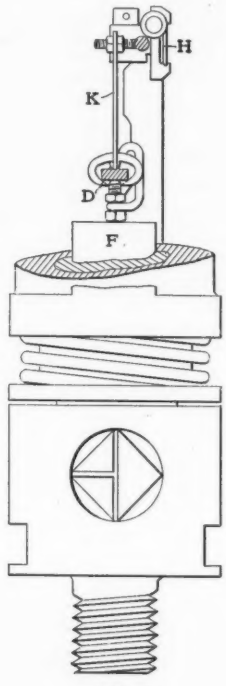


FIG. 3

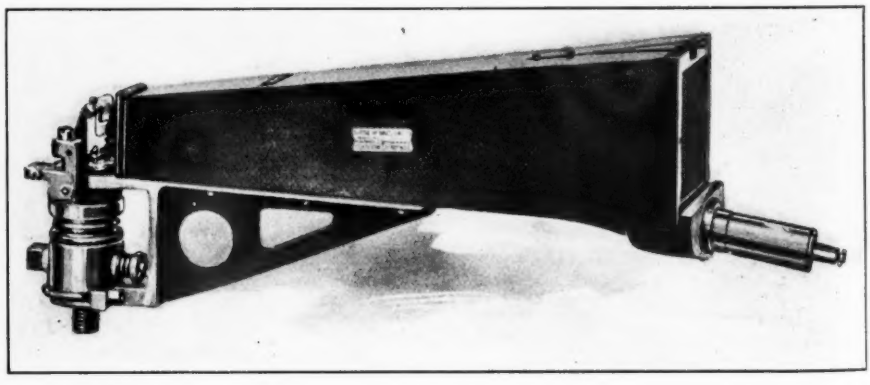


FIG. 4

shown. Before insertion it is slightly curved, but when in position it is held straight by a moderate pressure of the two binding screws. Above the spring, and parallel to it, is a spindle *I*, to the center of which a small mirror *H* is fixed.

illustrated, but in which an eccentric is fixed to the engine crank shaft, and a spring clip to the indicator head, although we understand that Dobbie-McInnes are prepared to supply better mechanical arrangements for most cases.

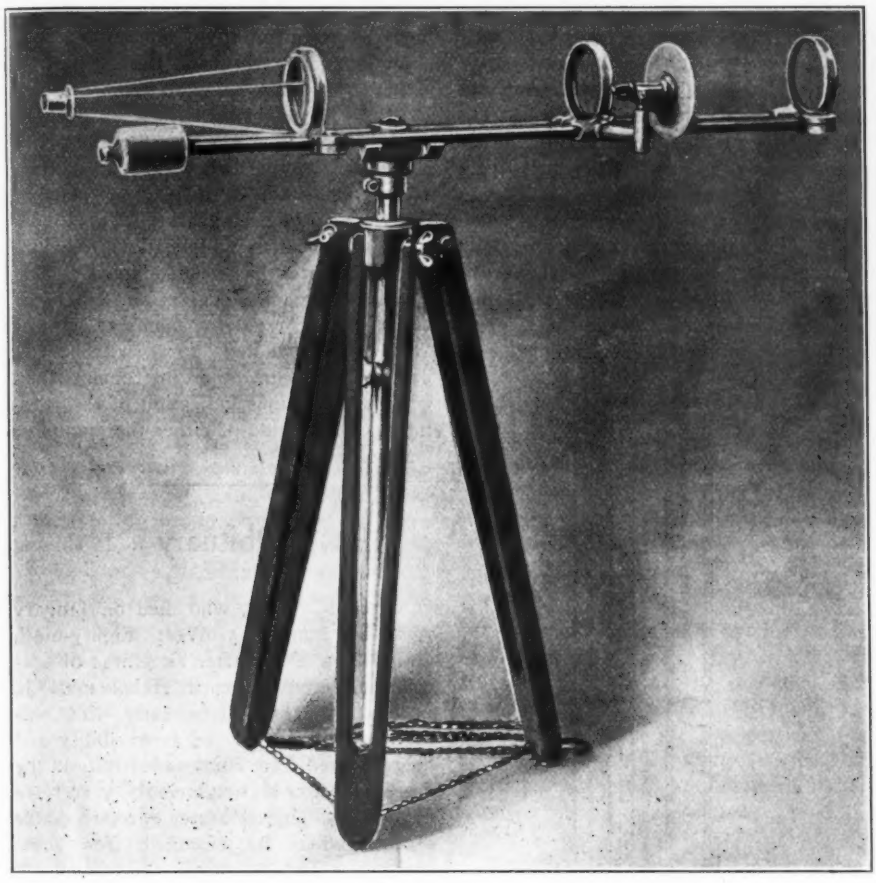


FIG. 5

The spindle is carried on pointed centers, against which spring clips press. It, and therefore the mirror, are caused to rock by means of a thin steel strip *K* connecting the spring and spindle, the flexibility of the strip allowing it to accommodate itself to the circular motion of the spindle. The length of the diagram is obtained by rocking the head of the instrument around the body, the motion taking place on the ball bearings shown in Fig.

To render the diagram visible, or to obtain a photographic record of it, a camera like that shown in Fig. 4 is attached to the indicator. A concave reflecting mirror is used, which throws a spot of light upon a ground-glass screen or photographic plate at the outward end of the camera. Should no permanent record be required, the object being simply to observe the pressure at any point of the stroke, or to note the general shape of

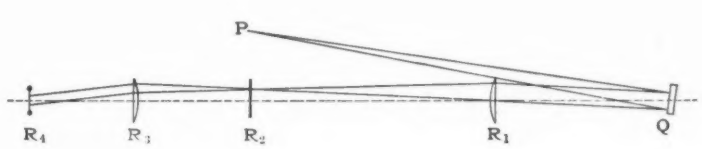


FIG. 6

2. A motion of the head through an angle of about 3½ degrees gives a diagram 2 inches long. The motion of the piston is only 1/40 inch, so that inertia effects are very small indeed. The indicator may be driven through a motion which is not

the diagram, a telescopic arrangement, as shown in Fig. 5, is used. The optical principle is illustrated in Fig. 6. The source of light is the filament of a 4-volt lamp at *P* placed transversely to a slit. The narrow beam thus formed is reflected from the plane mirror *Q* of the indicator upon the convex lens R_1, which is 4 inches in diameter, and situated about 18 inches from the mirror. The beam comes to a focus in the plane R_2. About 10 inches from R_2 is a second lens R_3, of the same

FIG. 7

size as R_1, which refracts the beam to R_4, where the eye of the observer is placed. A transparent screen, situated at R_2, is engraved with horizontal and vertical lines, on which the diagram appears superposed. Figs. 7 and 8 are reproductions of two indicator diagrams taken by the Hopkinson instrument, one from a gas engine and one from a steam engine. The diagram shown in Fig. 7 represents twenty explosion strokes, with a mixture containing about 11 per cent. of gas; that in Fig. 8 is from the low-pressure cylinder of an 11-brake-horsepower Belliss engine, running at 600 revolutions per minute. The scale of the original is about 12 pounds to an inch, and the diagram shows very well the small inertia of the instrument.

Three pistons are supplied with the indicator, their areas being in the ratio of 1, 2 and 4. The smaller ones are inserted in liners which fit into the bore of the instrument. Two springs are supplied, one five times as stiff as the other, so that by interchanging among the pistons and

FIG. 8

springs a wide range of scale is obtained. The initial strain on the springs, due to straightening out their natural curvature, allows suction pressures to be registered to the same scale as pressures above the atmosphere.—*Engineering.*

Veeder Liquid Tachometer

The liquid tachometer described and illustrated herewith is manufactured by the Veeder Manufacturing Company, Hartford, Conn. This instrument makes use of a liquid in a device similar to a

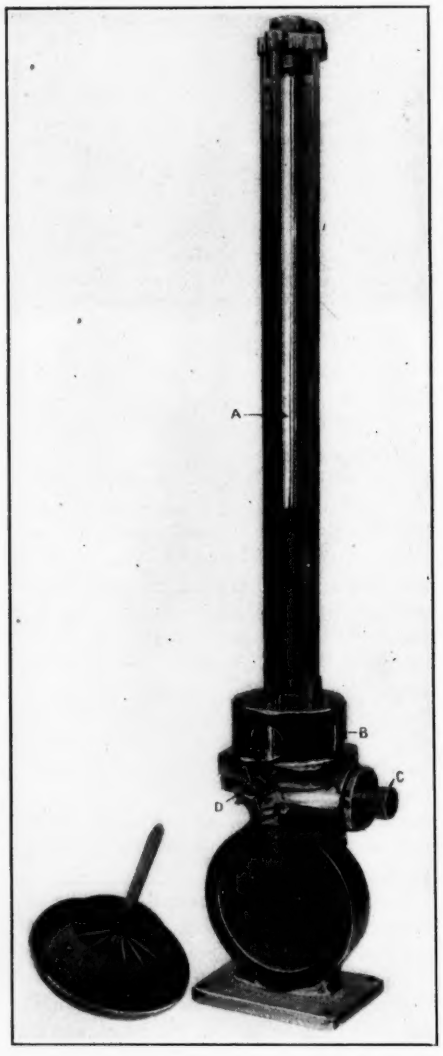


FIG. 1. VEEDER LIQUID TACHOMETER

centrifugal pump. Its principle in action is that the pressure developed by the centrifugal force of the liquid, when the instrument is running at a certain speed, is a definite quantity. This pressure forces liquid up the indicating tube *A*, Fig. 1, and is balanced by the pressure due to the hight of the column of liquid in the tube. Fig. 2 is a sectional view.

The instrument shown in Fig. 1 illustrates one of its present forms with the paddle removed. The only moving part is in the paddle, which imparts the necessary centrifugal force to the liquid contained in the body. A small reservoir *B* is located directly over the paddle case, in the center of which is a glass tube through which the liquid flows to the indicating tube *A*.

A suitable zero mark is provided around this small tube in the center of the reservoir. The liquid rises by capillary attraction in this small central tube somewhat above the level of the liquid in the reservoir. This enables the tachometer to be set at zero, a displacement clutch operated by small thumb nuts (shown at *C*) enabling the operator to raise or lower the hight of the liquid so that its surface shall be exactly at the zero mark.

A free passage is provided from the reservoir to the center of the paddle wheel, allowing the liquid to flow freely to the paddle wheel, from which it is thrown out through very small orifices in the periphery of the paddle case. A small handle *D* is placed at the front, with which to operate a valve to choke the passage from the pump to the indicating column. This is to prevent the dancing or vibration of the liquid column, due to

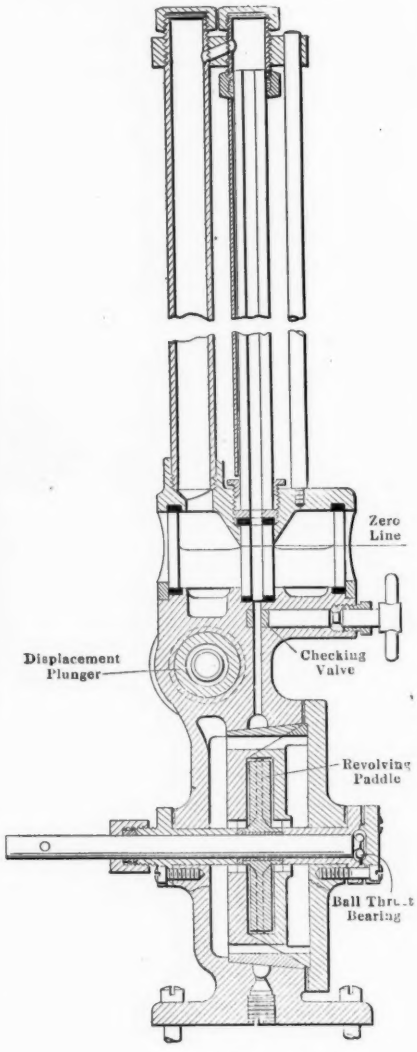


FIG. 2

any fluctuation in the speed of the revolving body whose revolutions are being indicated.

The blades of the paddle are radial so the device may be reversed. A ball thrust bearing is provided for the paddle shaft, thus eliminating any wear that would prove injurious. The outlets for the liquid consist of a number of small radial holes, equally spaced around the periphery of the paddle case.

The apparatus is so sensitive that at the maximum speed for which it has been constructed, namely, 2500 revolutions per minute, a difference of one or two revolutions is very noticeable. It is portable and there is no difficulty in holding the column practically vertical. It may be used either by holding it in the hand, the paddle-shaft wheel being driven by a short, flexible shaft thrust against the end of the revolving member whose revolutions are to be measured, or it may be fastened down and driven by gears.

Among the many applications to which the tachometer has been adapted is that of testing dynamos, engines and other machines having revolving members. It has also been adapted for switchboards, grouped with the other instruments, and gives a continuous indication of the revolutions per minute of either the engine or generator.

Obituary

Alfred R. Wolff, who died on January 7, at his home, 15 West Eighty-ninth street, New York, after an illness of several months, was born in Hoboken, N. J., March 15, 1859. His early life was marked by evidences of great ability and he graduated from Stevens Institute in the first half of his eighteenth year. He entered the United States revenue cutter service, where he remained for some years, leaving to become assistant to Charles E. Emery. Later he became a member of the firm of Whitman & Wolff, consulting engineers, and afterward opened an office and devoted his energies to heating and ventilation. He was an engineer of rare ability and wrote to some extent on engineering topics, such as "The Most Economical Point of Cutoff," "The Windmill as a Prime Mover," "Value of the Study of the Mechanical Theory of Heat," "Expansion of Steam and Water," "Friction of Noncondensing Engines," "The Influence of Steam Jackets on the Pawtucket Pumping Engines," "Recording Pressure Gages," "Steam Consumption of Engines and Water Meters." He served on several committees for the American Society of Mechanical Engineers, among the most important of which was the committee on standard pipe sizes.

The annual stag banquet of the Louisville Association No. 1, N. A. S. E., was held Thursday evening, January 7, at 8:30 o'clock, at the Galt house, Louisville, Ky.

Three 3500-kilowatt Curtis horizontal turbo-generators will be installed in the new power house of the California Electric Generating Company, Oakland, Cal.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Alternating and Direct Current

What is the difference between alternating and direct current, as regards direction of flow?

R. B.

Alternating current flows alternately in opposite directions; direct current flows always in one direction. Read the editorial on page 335 of the August 25 number of POWER AND THE ENGINEER.

Absolute Terminal Pressure

Will you please explain what is meant by absolute terminal pressure?

A. W. P.

The term "absolute," as used in speaking of steam pressures, means pressure reckoned from a perfect vacuum of 14.7 pounds below atmospheric pressure. The absolute terminal pressure would be the terminal pressure reckoned from vacuum and expressed in pounds pressure absolute. If the terminal pressure were two pounds absolute, it would mean that the pressure was 12.7 pounds below the pressure of the atmosphere, or about 26 inches of vacuum.

Cylinder Ratio for Compound Engines.

What is the proper cylinder ratio for compound engines?

E. H. S.

This must be settled by the conditions under which the engine is to be operated. With a steam pressure of from 125 to 200 pounds, if the engine is to run noncondensing, the cylinder ratio that will probably be found to be the best will range from 2½ to 1 to 3 to 1. For condensing engines with a fairly steady load, and for steam pressures from 125 to 150 pounds, a cylinder ratio of from 4 to 1 to 5 or 6 to 1 will give economical results.

With noncondensing engines there is little to be gained by compounding for a steam pressure of less than 125 pounds.

Ratio of Expansion

Will you please explain what is meant by ratio of expansion and how to find it?

M. O. D.

Ratio of expansion is the proportion the total volume of the steam in the cylinder bears to the volume at cutoff. To find the ratio of expansion, divide the stroke in inches by the number of inches of the stroke completed when cutoff takes place. To be exact in calculating the ratio of expansion, the clearance must be known and taken into account. If, for instance, the effect of the clearance is such that it adds 1 inch of cylinder length to the volume of the cylinder at each end, this must be added to the stroke of the piston and to the piston travel before cutoff. Suppose the stroke of the engine to be 30 inches and the cutoff to take place after the piston has traveled 6 inches. Nominally the cutoff would be at one-fifth stroke and the ratio of expansion would be 5, but actually the cutoff would be 7/31 of the stroke and the ratio of expansion would be 4.428.

The Horsepower of Belting.

I have a belt, 16 inches wide, passing over two pulleys, each of which is 5 feet in diameter and running at 200 revolutions per minute. What is the greatest limit of horsepower that it will transmit?

W. M. C.

There are a great many different rules for calculating the horsepower of belting, all based on the results of practice under different conditions. One rule very commonly used says that a belt 1 inch wide running 1000 feet per minute will transmit one horsepower. In your case you have a belt 16 inches wide running 3140 feet per minute and, according to the rule, it will transmit

$$\frac{16 \times 3140}{1000} = 50.24$$

horsepower. Another rule says that at 70 feet of belt surface per minute one horsepower will be transmitted. Applying this rule you will have

$$\frac{3140 \times 1.33}{70} = 59.65$$

horsepower. These rules are meant to be applied to single belts. Double belts will transmit from 70 to 100 per cent. more power than single ones. They may also be overloaded 200 or 300 per cent. for some time, but this practice destroys the elasticity of the belt and shortens its life.

Book Reviews

THE STEAM TURBINE. By James Ambrose Moyer. John Wiley & Sons, New York. Cloth; 370 pages, 6x9 inches; illustrated. Price, $4.

The author has been instructor of experimental engineering at Harvard, has been an engineer on experimental work in the steam-turbine department of the General Electric Company, and is now engineer with Westinghouse, Church, Kerr & Co., so that he is well equipped to treat the subject, both by analysis and from observation. The book is intended as a manual for the practical engineer, who is designing, operating or manufacturing steam turbines, "rather than a compilation of manufacturers' catalogs combined with a digest of standard books on thermodynamics and mechanics." It was intended primarily for the use of the author's assistants in the experimental, testing and engineering departments of the companies with which he is connected. An introduction of nine pages tells of the development of the turbine and includes the familiar pictures of the productions of Hero and Branca, without which no writer upon the subject seems able to get started. A chapter upon the Elementary Theory of Heat explains the entropy diagram and the calculation of the available energy in steam in an easily understandable way. The real turbine work starts with a chapter on Nozzle Design, followed by one on Blade Design. Mechanical Losses in Turbines are then considered, and a chapter devoted to the Method for Correcting Steam Turbine Tests. Seventy-eight pages are then devoted to the description of commercial types. Succeeding chapters deal with Governing, Low-Pressure Turbines, Marine Turbines, Testing, Steam Turbine Economies, Stresses in Rings, Drums and Disks, Gas Turbines, and Electric Generators for Turbines. The book is written in such a way as to be understood by the practical engineer of moderate attainments and is an excellent presentation of the things which a turbine man ought to know by a man who has had exceptional opportunities for finding them out, and who knows how to tell them simply and well.

CYCLOPEDIA OF CIVIL ENGINEERING. By Frederick E. Turneaure, editor-in-chief (dean of the College of Engineering, University of Wisconsin), assisted by a corps of civil and consulting engineers and technical experts. Published by the American School of Correspondence, Chicago, Ill. Eight volumes, each containing about 400 pages, 7x10 inches, with more than 3000 illustrations, all told.

It would be next to impossible properly to review this encyclopedia in these columns; therefore, no attempt will be made to do so. It is a general reference work on Surveying, Railroad Engineering, Structural Engineering, Roofs and Bridges, Masonry and Reinforced Concrete, Highway Construction, Hydraulic Engineering, Irrigation, River and Harbor Improvement, Municipal Engineering, Cost Analysis, and kindred topics. The list of authors and collaborators includes the leaders in the fields designated. In addition, the standard technical authorities of America and Europe were freely consulted and the best that they have to offer has been incorporated in this work.

The aim has been throughout to create a work which, while adequate to meet all demands of the technically trained expert, will appeal equally to the self-taught practical man, and apparently that object has been attained. The work covers not only the fundamentals that underlie all civil engineering, but their application to engineering problems of every sort. In effect, it is a compilation of representative instruction books of the American School of Correspondence, incorporating what is believed to be an ideal method for the education of the busy workingman. The volumes are handsomely bound, the paper, type and illustrations are excellent and, altogether, it is a work which it will pay every reader of this paper to have in his library.

Business Items

W. H. Smead, formerly mechanical engineer for the General Fire Extinguisher Company, Atlanta, Ga., has opened an office for himself in the McAdoo building, Greensboro, N. C., where he will make a specialty of designing steam-power plants and heating systems. While with the fire-extinguisher company he designed the power piping for the New Orleans water-works, White Oak Cotton Mills and other plants.

James H. Jarvis, chief engineer of the Charlotte General Electric Company, of Charlotte, Mich., has sent a letter to C. P. Bassett, of Charlotte, manufacturer of the McNaughton grate bar, in which he says: "We have had some of your McNaughton sectional grate bars in use for more than a year and we find them to be very economical of fuel. They do not overheat or clog and they are just as straight as the day they were put in, the construction of the bar being such that they will not warp, and they make a nice even surface to fire on."

The business heretofore carried on by the American Engineering Specialty Company, with headquarters at Chicago, and branches and agents in various cities through the middle West is now conducted in the name of Warren Webster & Co., with main office and works at Camden, N. J. This change will give to architects, engineers, contractors, users and intending purchasers of "Webster" apparatus the full advantages of the "Webster" organization, which now covers all parts of the country. It implies no change in the personnel. The same representatives with whom the trade is already acquainted will be glad at all times to give inquiries their best attention.

The Northern Electrical Manufacturing Company, Madison, Wis., announces the enlargement and removal of its St. Paul district office to 1046 Security building, Minneapolis, Minn. This betterment of their sales office facilitates closer relation with their customers in the twin cities and improves their office surroundings. T. E. Drohan, who has been representing them in the St. Paul office, will continue in charge of the Minneapolis office. His experience as superintendent of the Northern works makes it possible for him to serve customers in his territory to excellent advantage, as his sales interest is coupled with an intimate knowledge of manufacture and design.

Methods of cooling water for steam-condensing and other plants are fully described in Bulletin 104, "Water Cooling Towers," just issued by the Wheeler Condenser and Engineering Company, of Carteret, N. J. After explaining the physics of water cooling, the different types of cooling tower are discussed, more especially the Wheeler-Barnard tower, the essential feature of which is the use of galvanized, woven-wire mat as the "filling" medium over which the water trickles. This tower is built in the forced-draft, natural-draft and open styles, and the numerous full-page illustrations adequately show its construction and manner of installation. There are also various tables on humidity, air and vapor mixtures, etc., which should be of value to engineers.

The Westinghouse Machine Company reports good progress during recent months in the steam-turbine business, despite the general depression existing in the machinery market. While business has been considerably below normal, there have been many encouraging features in all directions of power application. Out of the most important business covering some twenty machines ranging in size up to 10,000 horsepower, they find the usual activity in electrical, power and traction work, and a fair demand from various industries, including phosphate, cement and rubber mills, steel car works and oil refineries. Inquiry for exhaust steam turbines is active, and several equipments have been contracted for. While there have been important power extensions in turbine equipment, the steam-engine business of the Westinghouse Machine Company has been fairly active, as is evidenced by the number of orders for engines recently received.

Cia Azucarera del Panuco, Tampico, Mex., has placed an order with the Westinghouse Machine Company for a complete producer gas-electric power plant. This initial installation will consist of a vertical, 3-cylinder, single-acting engine and a 150-horsepower suction producer, designed to operate on small anthracite. The use of the suction producer in such large sizes has proven thoroughly practicable, and considerable business is anticipated along this line. Even larger sizes of producers of the suction type are contemplated by the builders. The New York Standard Watch Company, of Jersey City, N. J., also operates a suction producer gas plant of considerable size, and recently added another unit to its plant. A number of contracts have been let for gas engines operating temporarily on natural, or illuminating gas, with the intention of later changing over to producer-gas operation. A 200-horsepower plant has been ordered by Seaver & Co., Chelsea, Mass., and by the Cambridge Gas Company, Cambridge, Md. The Shelbourne Falls (Mass.) Electric Light Company has adopted the power gas system and has ordered a 175-horsepower Westinghouse suction producer for anthracite.

C. S. Davis, president of the William B. Pierce Company, of Buffalo, N. Y., recently gave out the following interview: "Notwithstanding the business depression of the past year, we have more than held our own in business. The fact that we have increased both our factory and office forces during the past year would seem to bespeak a healthy state of affairs. The fact of the matter is, our proposition, the Dean boiler-tube cleaner, is a fuel saver of the first order. As a rule in busy times people are prone to overlook the loss of fuel due to scale. Then, too, lots of fellows are willing to let 'well enough' alone. 'Maybe we have scale, as you contend,' they tell us, 'but we really haven't the time to investigate.' So the waste goes on. Well, this past year our words fell on fertile soil. People wanted to cut down expenses. They had time to investigate. Were they wasting coal? Did they have scale without their knowing it? Here was an opportunity to find out. Lots of concerns, with only remote thought of purchase, ordered the Dean on trial just to ascertain its merits. When they saw what the Dean did, they were only too glad to send us their check. So, we reaped a good harvest."

New Equipment

The Orofino (Idaho) Electric Company is constructing a hydroelectric plant.

The Seattle (Wash.) Ice Company is erecting a new plant, which is to cost $300,000.

The Merchants Power Company, Memphis, Tenn., is erecting an addition to its plant.

The citizens of Tacoma, Wash., will vote on proposition to build a municipal power plant.

The citizens of Conroe, Texas, voted to issue $77,000 bonds for construction of water-works.

St. Joseph's Hospital, Baltimore, Md., has awarded contract for the erection of a power house.

The Findlay (Ohio) Table Manufacturing Company will install a new steam turbine in its power plant.

The Cincinnati (Ohio) Traction Company has filed plans for a new power house to cost about $32,000.

It is said the Paxton (Ill.) Electric Company is considering plans for the installation of a 20-ton ice plant.

The Humbird Lumber Company, Sandpoint, Idaho, is considering plans for a power plant in connection with mill.

W. T. Wingate has been granted franchise by the City Council to operate an electric light system in Maysville, Mo.

It is reported that the Merchants' Heat and Light Company, Indianapolis, Ind., will erect an additional power house.

The Fairfield (Iowa) Gas and Electric Company contemplates remodeling plant at an expenditure of about $40,000.

The Kentland (Ind.) Light and Ice Company is planning to build an electric light, water and ice plant. Hugh Hill, president.

The Independent Ice Company, Nashville, Tenn., has been granted permit to erect factory building, boiler and engine rooms.

It is reported that the Citizens Electric Company, Williamsport, Penn., will install additional boilers, engines and generators.

The Charleroi (Penn.) Water Company is considering the installation of a filtration plant and a new duplicate pumping station.

Bids will be received until 11 a.m., Feb. 5, by Capt. C. H. Lanza, Key West, Fla., for furnishing condenser, filter, feed-water heater, etc.

The Prospect Rock Heat, Light and Power Company, Georgetown, Penn., is being organized, and site has been secured for power house.

It is reported that the City Council, Kearney, Neb., has passed an ordinance providing for the issuance of $100,000 bonds for water-works system.

The Paulding County Electric Company is asking bids on dam and power house to be erected on Punking Vine creek, near Dallas, Ga. W. S. Lotus, of Dallas, is president.

The citizens of Blacksburg, S. C., voted to issue $15,000 bonds for the construction of an electric light plant, etc. P. H. Freeman is chairman of Public Works Commission.

Bids will be received until Feb. 2 by the board of Water Commissioners, Kenosha, Wis., for a horizontal cross-compound high duty pumping engine of 6,000,000 gallons capacity in 24 hours.

The Southern New Hampshire Street Railway Company is contemplating the erection of a new power station in Methuen, Mass. The present power plant is located at Portsmouth, N. H.

It is reported that the Rock Island Southern Railroad Company will shortly place contracts for the construction of power plant on Edwards river. W. W. McCullough, Monmouth, Ill., is general manager.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AGENTS to sell one of the best known and widely advertised shaking grates on the market. Exclusive territory granted to any-one who can make good. Liberal commission. Perfection Grate Co., Box 1081, Springfield, Mass.

WANTED—A practical mechanical engineer and machinist who thoroughly understands steam and gasolene engines. Must have means to invest in the best thing he ever saw, and make our rotary engine his life work. Parent company organized and three 15 horsepower engines running. Best of references required. Motsinger Rotary Engine Company, Greensburg, Pa.

Setting the Valves of the Cummer Engine*

An Old Time Engine with Special Eccentric Shaft. A Study of Valve Movement and Explicit Directions for Overhauling and Valve Setting

BY H. E. COLLINS AND J. H. FRANCIS

The Cummer engine is probably not as well known as many of our American automatic cutoff engines, due largely to the fact that not many engines of this type have been built in the past 15 years. Previous to this time, say from 1884 to 1893, quite a large number were built ranging in sizes from 50 to 3000 horsepower. Nearly every State in the Union has one or more Cummer engines in use at the present time, and consequently there are many engineers more or less interested in a description of a simple method of setting the valves on this engine. A description of the valves, the valve mechanism and the governor might also be of interest to some not familiar with this type of engine.

The general design and arrangement of the engine is shown in Fig. 1. The cylinder is provided with two steam valves, two cutoff valves and two exhaust valves. These valves are of the flat grid-iron type, and the seats for the steam valves are vertical, being on the side and at each end of the cylinder. Each seat has three steam ports. The exhaust-valve seats are horizontal, and located under the steam chest.

The exhaust-valve stem connects to the lower end of a rocker arm which is pivoted at its center and located about the center of the frame. To the upper end of the rocker is connected the steam-valve stem and also the eccentric rod, thus giving the steam valve a direct motion with the main eccentric, while the exhaust valves travel in the opposite direction. The valves all move toward the center of the cylinder in opening and toward the ends of the cylinder in closing. The cutoff valve has two ports and its stem is connected to a slide to which also is attached the cutoff eccentric rod.

The eccentrics are mounted on a shaft running parallel with the crank shaft and driven by a train of three spur gears inclosed in an oil-tight case, which also serves as a bearing for one end of the eccentric shaft and the intermediate-gear spindle. This arrangement gives the same direction of rotation to the eccentrics as to the crank and the same speed, as the gears are all of the same size. The advantages claimed for this arrangement are a smaller shaft for the governor and consequently smaller eccentrics, and, of course, less friction by virtue of this. The arrangement allows also for the eccentrics being set in line with the valves, so that they can be driven directly without offset eccentric rods. As the eccentrics are smaller than would be required on the

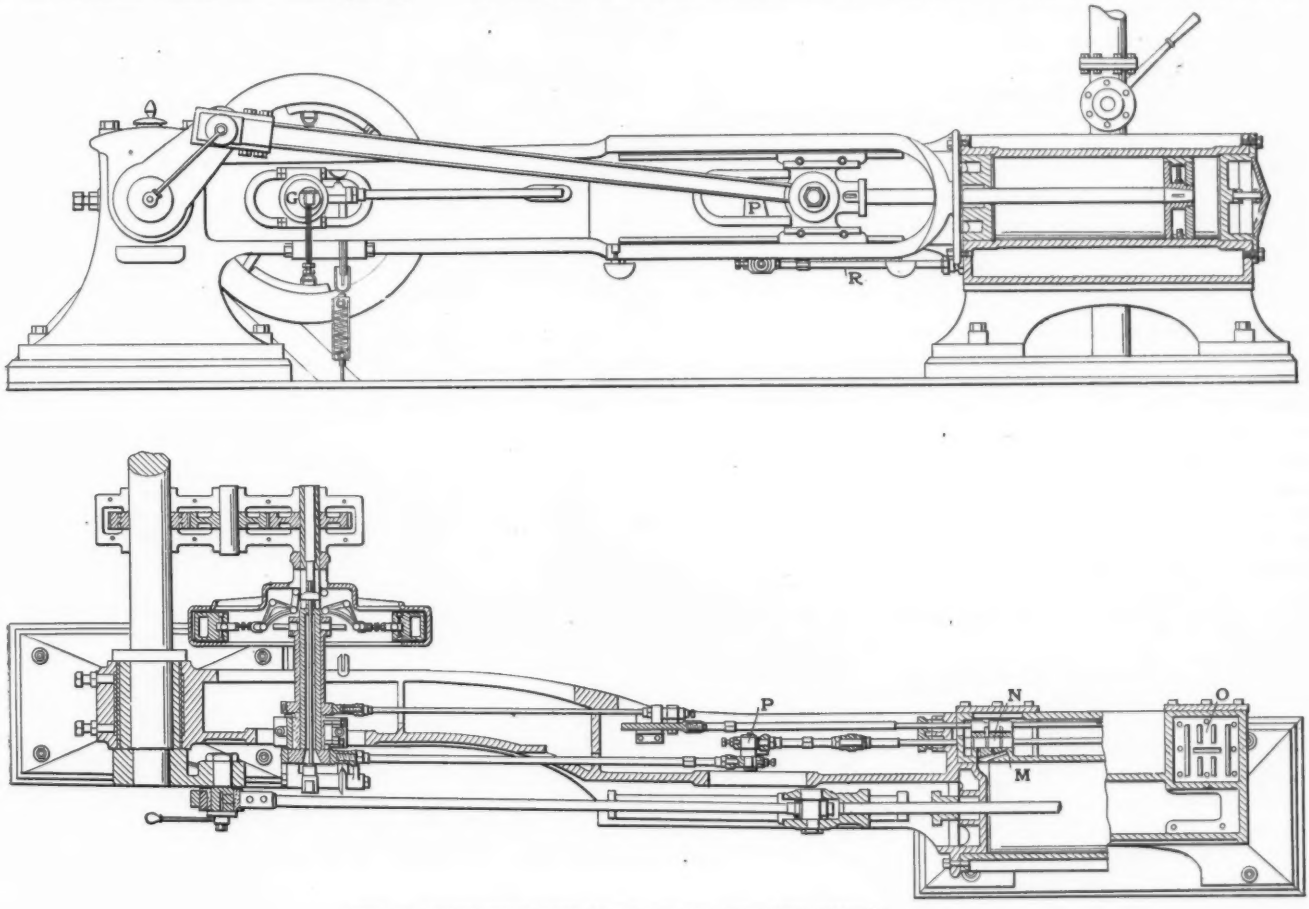


FIG. 1. ELEVATION AND PLAN OF THE CUMMER ENGINE

*Two articles were received simultaneously on this subject and have been combined in the presentation herewith.

main shaft, a shorter range of movement for the governor to operate the cutoff eccentric is obtained. With this particular design the working range of the governor is reduced to one-fourth that of many other designs. Another feature of this governor is the fact that speed changes can be made while the engine is running.

In Figs. 1 and 2 the main eccentric is at *G* and the cutoff eccentric at *H*. The main valve on the crank end is at *M*, the cutoff valve at *N*, and the exhaust valve seat on the head end at *O*. The main eccentric rod is connected to the top end of a reciprocating rocker *P*, from the lower end of which the exhaust valves are driven by the exhaust rod *R*.

By referring to Fig. 2 a clearer understanding of the governor and eccentric arrangement will be obtained. It will be noted that the eccentric shaft has one bearing in the engine frame at *S* and the other in the gear case at *T*. The governor case and cutoff eccentric ride on the main eccentric shaft, the cutoff eccentric and sleeve slipping on the shaft up to a shoulder, and extending back to the collar *U* which clamps to the cutoff-eccentric sleeve. The collar *U* has two pins to which are attached the links *V V*, shown in Fig. 3, so that when the weights *W W* fly out, they act on the cutoff eccentric, throwing it forward in its travel, or back when the weights come in again. The action of these weights is held in check by the weight and spring attached to the large bell crank *X*, shown in Fig. 2, which is under the engine frame and pivoted at *Y*. On the other end of this shaft is a rocker arm which acts on the thrust rod *A* in the hollow governor shaft. At the end of the rod is a crossbar *B* which extends through slots in the governor shaft. To each end of the crossbar *B* are attached the links *C C*, which in turn are attached to the small bell cranks *D D*, pivoted at *E E* and secured to the governor weights *W W* by the adjustable links *F F*.

With this arrangement the weight and spring on the large bell crank tend to hold the thrust rod in a direction toward the gear-case end of the shaft, and through the crossbar *B* and the bell cranks *D D* tend to hold the weights *W W* always toward the shaft center. Aside from friction the work that the centrifugal force of the governor weights has to do is to lift this dead weight and overcome the spring tension, and when it does that or is in turn overcome by these forces, the changing position of the governor weights operates the cutoff eccentric. By turning the screw *G'*, Fig. 2, the tension can be altered, and the purchase of the spring on the lever can be changed by putting the pin *H'* through any one of the holes provided for it. The dead weights can be lifted off or placed in position while the engine is in motion.

In Fig. 4 the main steam valve, the cutoff valve and the exhaust valve are shown in plan and section. The main valve admits steam through its three ports direct into the cylinder ports, and the cutoff valve uses one of its outside edges for a cutting edge and thus controls the three ports of the main valve with its two. In the same way the exhaust valve, with only three ports, controls the four exhaust ports under it. Figs. 5, 6 and 7 show more clearly the arrangement of the valves in the cylinder. The main valve *M*, cutoff *N* and exhaust *G'* can all be located.

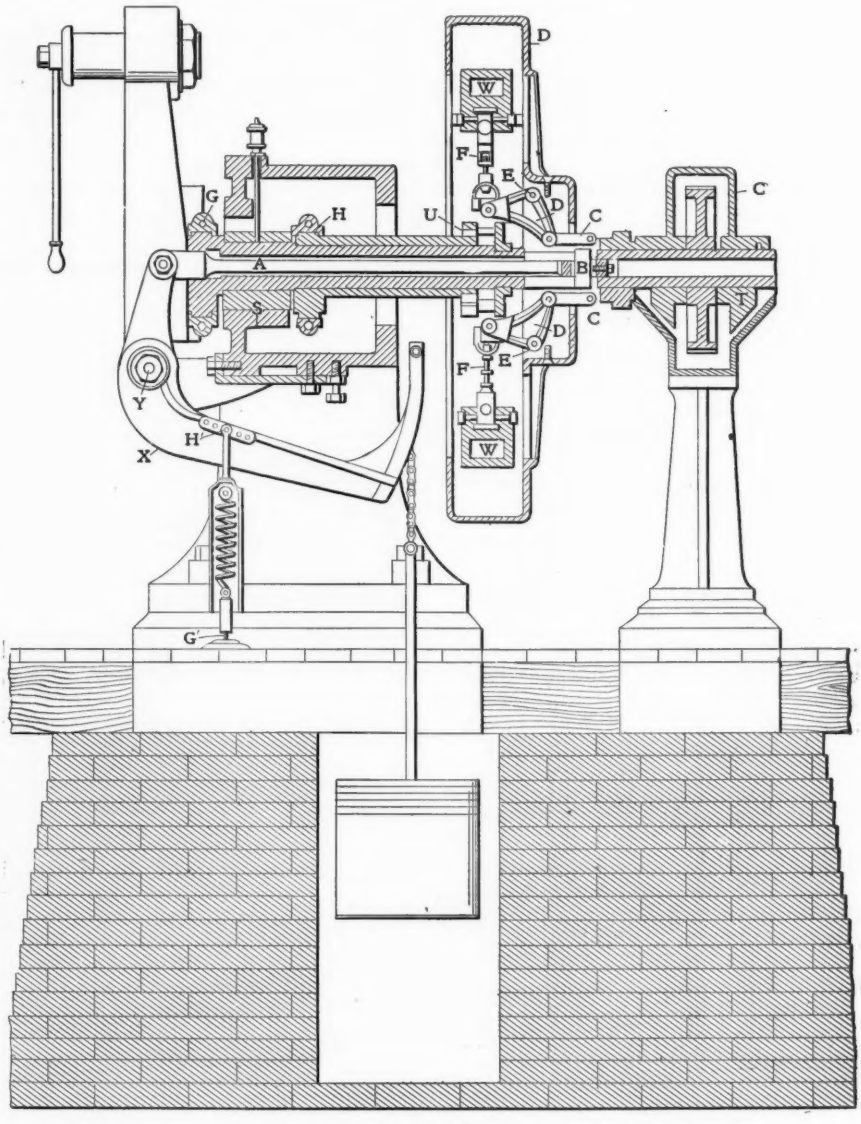


FIG. 2. VERTICAL SECTION ALONG THE CENTER LINE OF THE GOVERNOR SHAFT

Steam enters the steam chest *H'* at the top and passes the main and exhaust valves into the steam port *I'*, exhausting into port *J'* through exhaust valve *G'* into the exhaust passages *K'* and finally out at *L'*. The valve stems *K*, *L* and *R* in each case extend through the entire length of the steam and exhaust chests respectively.

The cylinder is equipped with six separate valves, two on each valve stem, or in other words three separate valves in six parts do the work of one ordinary slide valve.

Valve Action During One Revolution

Figs. 8 to 17 inclusive are used to illustrate the relative positions of all the valve edges for a given position of the crank and under varying conditions. In these illustrations the main steam and cutoff valves are shown in section over the steam ports for convenience in grouping and to avoid the use of dotted lines. As the true relative position of the valves in the cylinder are shown in the previous illustrations, this arrangement should cause no confusion.

In Fig. 8 the valves are all shown central on their travel over their respective ports. On the center line *A B* in each illustration are shown the valve circles or diagrams. The cutoff valve has greater travel than the main steam and exhaust valves, and the larger circle denotes the path of the cutoff eccentric, the inner circle denoting the path of the main eccentric. The position of the crank will be shown at *C*, the main eccentric at *M* and the position an exhaust eccentric would occupy at *E*, while the position of maxi-

mum cutoff is shown at *C O*. It will be noted in Fig. 8 and succeeding figures that the outside edges and inside edges of the cutoff-valve ports are the cutting edges, while the inside edges of the main steam-valve ports are the admission and cutoff edges for that valve. For the exhaust valve the outside edges of the valve and the inside edges of the ports are the working edges. To return to Fig. 8, the crank *C* is on the head-end center with the eccentrics and valves central. In Fig. 9 the eccentrics are advanced to the proper positions for operation with the crank *C* on the head-end center. The angle of advance for the main eccentric *M* is 30 + 90 degrees ahead of the crank *C*, and the cutoff *C O* is advanced to 30 degrees beyond the main eccentric for the position of maximum cutoff. In this position of the eccentrics the main valve should have from 1/32 to 1/16 inch lead and cut off at about eight-tenths of the stroke, the cutoff valve performing its function at the same time. It will be further noted that the main valve on the head end is open for lead and is traveling fast to overtake the cutoff valve which is moving in the same direction. This insures a full steam-port opening through both valves. The exhaust valve is open on the crank end and closed on the head end.

Fig. 10 shows the main eccentric *M* advanced to its extreme travel to the left, which allows the main valve to open full to the head-end steam ports and the exhaust valve to open full on the crank end, while the piston has advanced to about 25 per cent. of its stroke. It can be noted here why the cutoff valve is given wider ports than the main valve. To insure quick action on the cutoff, greater travel is given and for unrestricted port area, the cutoff ports must be wider. It will be noted that the cutoff valve does not restrict the main-valve ports, when the latter are open full to the cylinder ports, although the cutoff valve is now traveling opposite to the main valve. From this point the main and cutoff valves travel together, but the cutoff valve travels just enough faster to overtake the main valve and assist in the cutoff on the head end, when the piston has reached eight-tenths or more of its stroke, as in Fig. 11. In this figure the exhaust is also shown about two-thirds closed on the crank end and traveling toward release on the head end.

Fig. 12 shows the relative positions at the point of exhaust closure on the head

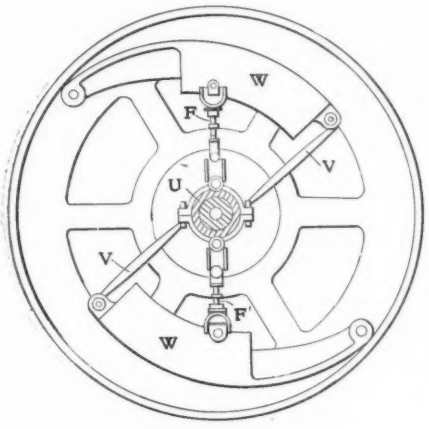


FIG. 3. GOVERNOR WHEEL

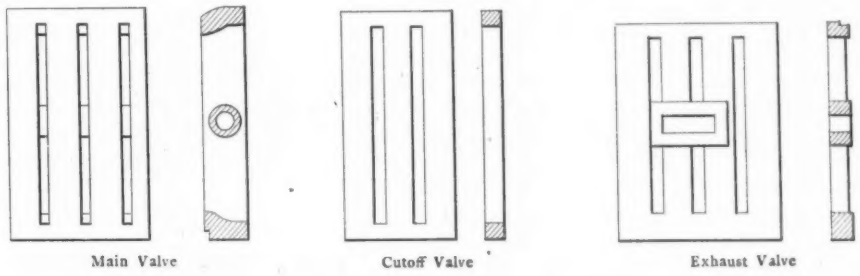


FIG. 4. VALVES OF THE FLAT GRIDIRON TYPE

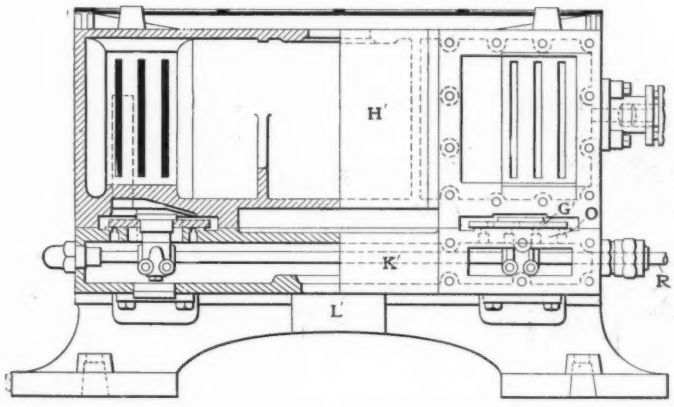


FIG. 5. ELEVATION AND PART SECTION THROUGH STEAM CHEST

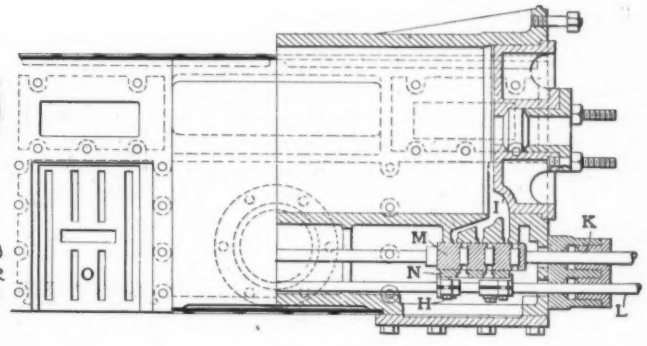


FIG. 6. HORIZONTAL SECTION THROUGH THE CYLINDER

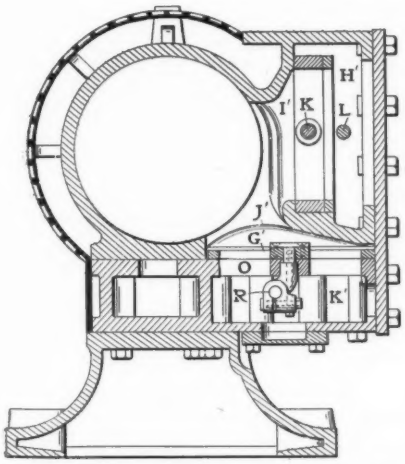


FIG. 7. TRANSVERSE SECTION THROUGH CYLINDER

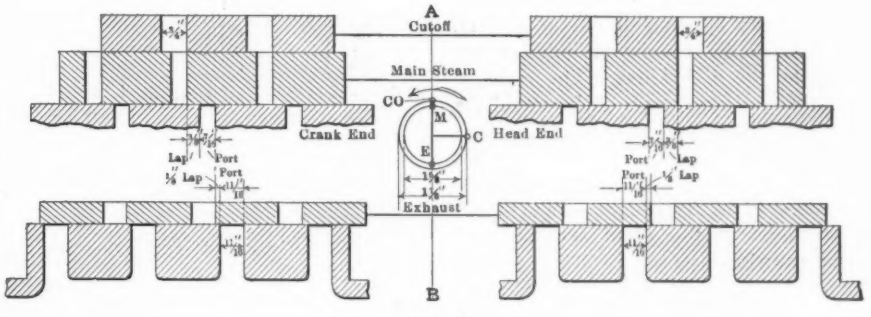


FIG. 8

end. The piston has traversed about 95 or 96 per cent. of its stroke, with the exhaust closing on the crank end. On the head end release will occur immediately at about 97 per cent. of the stroke. The cutoff valve still covers the main valve ports on the head end, but the eccentric *M* is now moving the fastest and will cause the main valve to overtake the cutoff by the time the piston has reached the end of its travel. This is shown in Fig. 13, where the crank *C* has reached the crank-end dead center. Here the main valve is shown open for lead on the crank end, and the head-end exhaust is open for release.

Fig. 14 shows the crank *C* advanced to the position opposite to that in Fig. 10, but the piston is not advanced as far on its return stroke as it was for the same angle of advance of the crank *C* on the other end. In other words when the crank-end steam ports are full open, the piston is at an earlier point of its stroke than on the head end. The head-end exhaust is also shown full open.

Fig. 15 shows the main steam and cutoff valves at the point of cutoff for the crank end, the exhaust traveling toward closure on the head end. In Fig. 16 the valves have advanced to the point of exhaust closure on the head end, from which point all parts will again reach the positions shown in Fig. 9. On account of the angularity of the connecting rod, all the functions of the valve are performed at an earlier point in the piston stroke on the crank end than on the head end.

The diagrams shown in Figs. 8 to 16 inclusive, represent valve action with the governor centrifugal weights at their inner position and the cutoff eccentric *C O* in the position shown. To give a minimum cutoff the *C O* eccentric must be advanced to the position of minimum cutoff, as shown by the full line in Fig. 17, the position for maximum cutoff being shown by the dotted line. The crank *C* has advanced far enough on its travel for the piston to have moved about one-thirtieth of its stroke. At that point the cutoff valve should cut off for minimum operation. The relative positions of the other valves at this point are indicated in the drawing.

Overhauling the Engine

In overhauling an engine it would be well for the engineer to examine the exhaust-valve clamp where it fits in the exhaust valve. As a rule, considerable lost motion develops at this point and some of the travel of the valve is lost. The ends of the slots in the valves should be dressed out, and a steel plate riveted to the side of the clamp. The clamp can then be fitted snugly into the valve. Care should be taken that the valve-stem hole is parallel with the face of the exhaust valve; also note that the travel of the thrust rod, which connects to the large

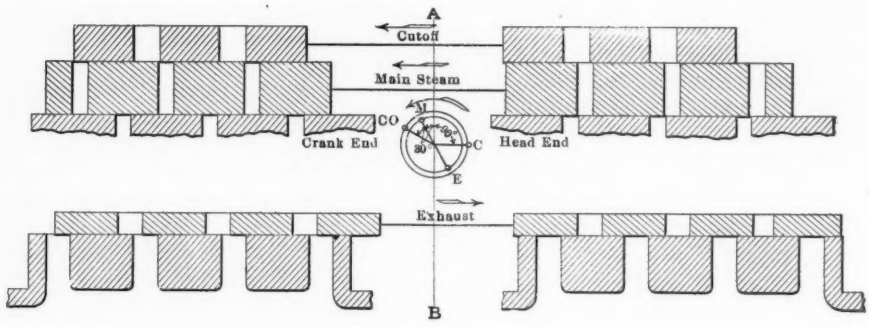


FIG. 9

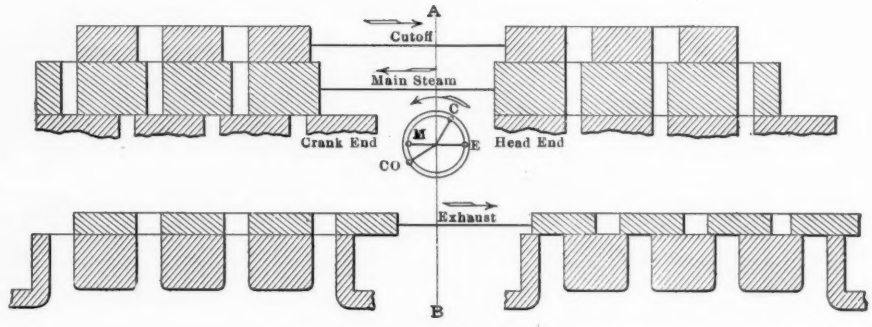


FIG. 10

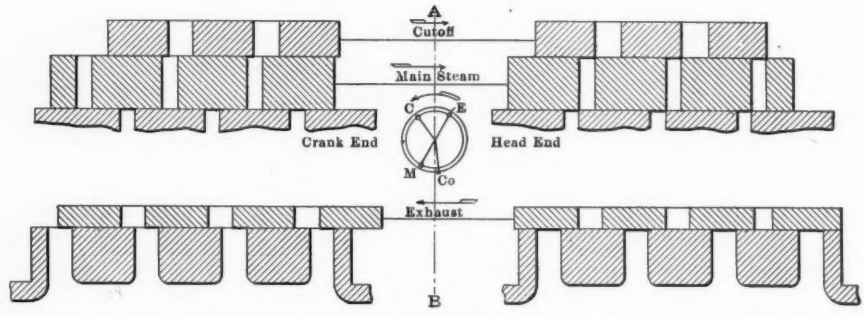


FIG. 11

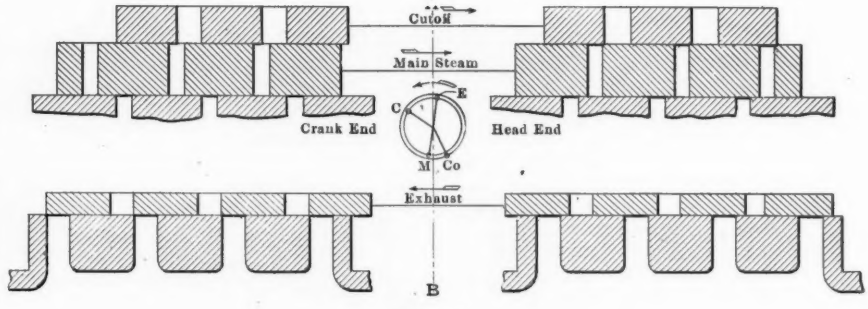


FIG. 12

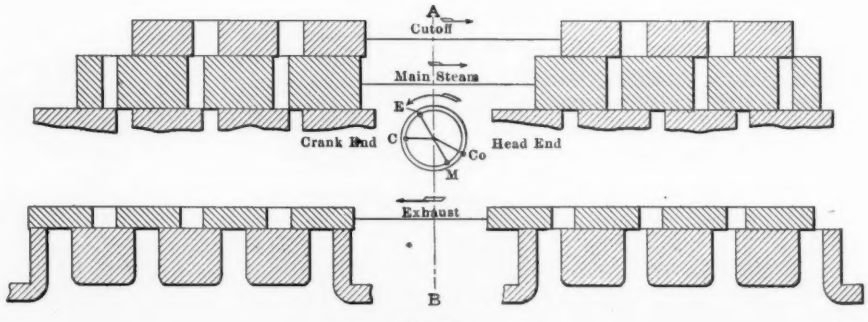


FIG. 13

bell crank, should be about 2½ inches for a 10x20-inch, up to 3½ inches for engines with 48-inch stroke. If for any cause this amount of travel is not obtained, the range of the cutoff is limited. It has been discovered on several engines where the governor had been dismantled for repairs, in the reassembling of the parts, the two knuckles that fit over the ends of the crossbar which passes through the governor shaft, had not been folded in between the two connecting links as shown at *A* in Fig. 18 or at *C* in Fig. 2. They had been connected as shown at *B*, Fig. 18, thus reducing the travel of the thrust rod about one-half, and instead of the engine being able to carry steam up to three-quarters of the stroke, the cutoff valve would close at less than one-half the stroke.

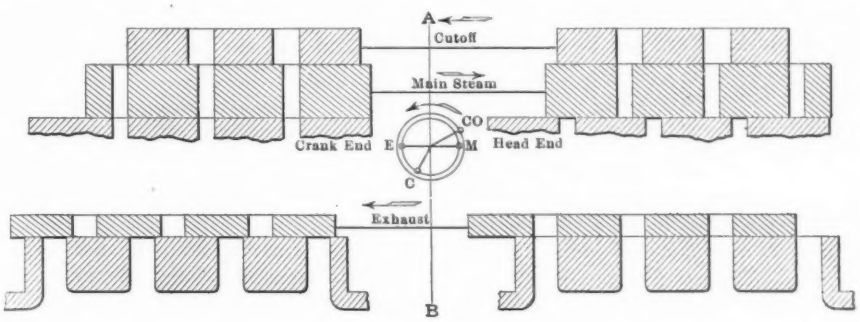


FIG. 14

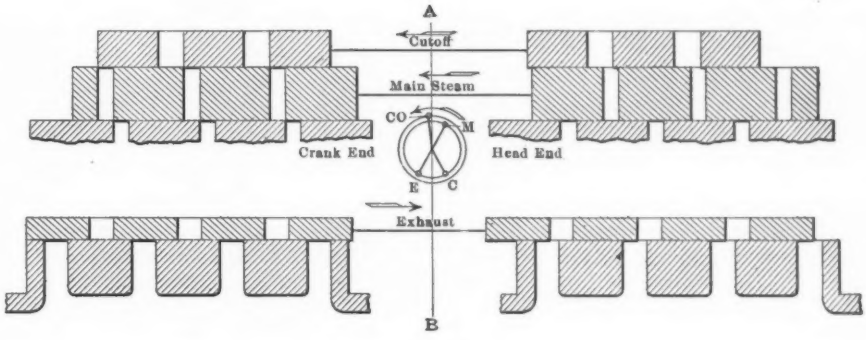


FIG. 15

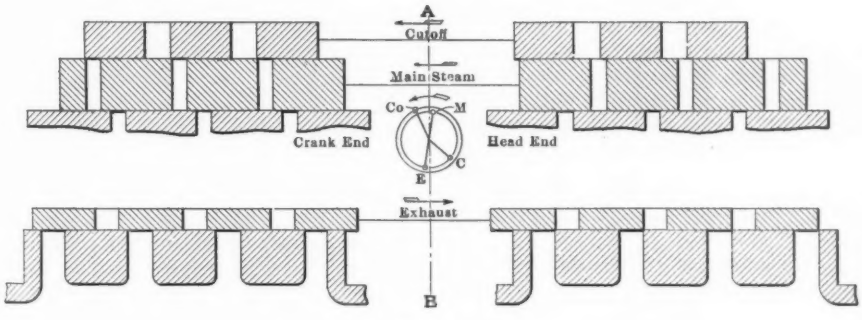


FIG. 16

Setting the Valves

It will now be assumed that the engine is connected and the points mentioned taken care of. The upper half of the gear case and the intermediate gear should be removed. The weights also removed, and the spring disconnected on the bell under the engine frame. Adjust the main and cutoff eccentric so that when the eccentrics stand plumb up or down the rocker arm is in exactly a vertical position, and the cutoff slide is central in the bracket. These rods can then be secured permanently. The next step is to locate the steam valves in the relation to the ports in the cylinder and the main eccentric. Turn the eccentric shaft so that the throw of the main eccentric is on a horizontal line with the center of the shaft and toward the crank shaft. Locate and clamp the steam valve at the head end of the cylinder so that the ports show full open. Clamp the valve temporarily to the valve stem. Turn the eccentric shaft through 180 degrees, or so that the throw of the eccentric is toward the cylinder, and locate the steam valve at the crank end of the cylinder in the same manner. Place the crank pin of the engine on one of its dead centers, say the one nearest the cylinder, and turn the eccentric shaft so that the steam valve at the head end of the cylinder shows about one-sixteenth lead. If the engine runs over, the relative positions of the crank pin and the eccentric will be as in Fig. 19. If the engine runs under, the pin and eccentric will be in the positions shown by the dotted lines.

The intermediate gear cover can now be placed in position, care being taken that the valve shows the proper lead when the gear is in place; clamp the exhaust valve at the crank end of the cylinder so there will be ¼ to 5/16 inch opening. Turn the engine in the direction it is to run. The steam valve should close at about three-fourths and the exhaust valve at about seven-eighths of the stroke. Turn the engine to the opposite dead center and adjust the steam valve on the crank end and the exhaust valve on the head end in the same manner. It may be necessary, if the exhaust valves do not open and close as desired, to advance or retard the eccentric one or more teeth of the driving gear. In case this is done the valves should be readjusted, giving them the proper lead as in the first trial. Up to this point the operation is similar to a slide-valve engine, with the exception that the steam and exhaust laps can be changed by either closing or spreading the valves on their respective stems. The setting of the cutoff valve is somewhat more puzzling, but if the following directions are carefully carried out no difficulty should be experienced.

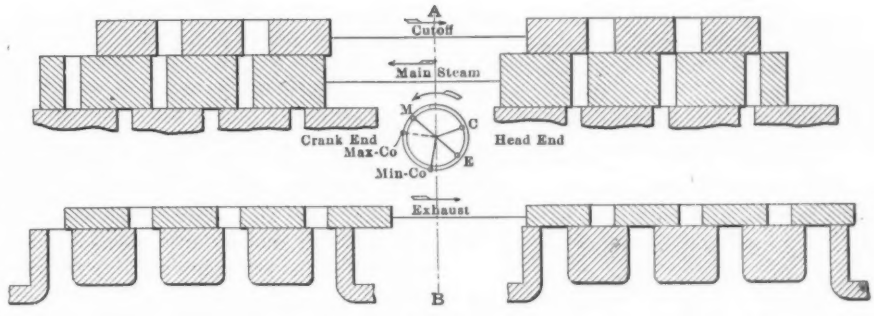


FIG. 17

The first step is locating the cutoff valve in relation to the steam valve and the cutoff eccentric. Turn the engine until the throw of the main eccentric is horizontal and toward the crank shaft. Now turn the cutoff eccentric, which as yet should not be connected to the governor weights, so that it stands in line with the main eccentric. Set the cutoff valve

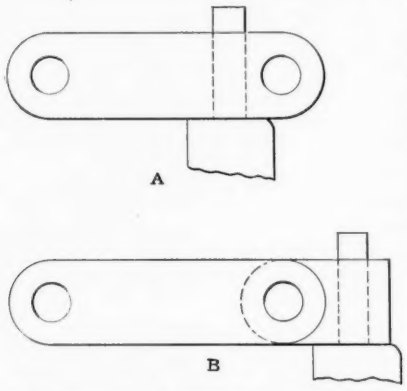


FIG. 18. A COMMON ERROR IN REASSEMBLING

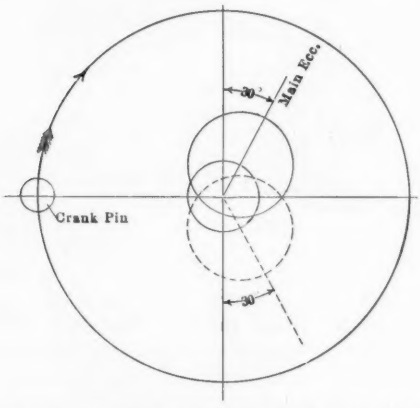


FIG. 19. RELATIVE POSITIONS OF CRANK AND MAIN ECCENTRIC AT DEAD CENTER

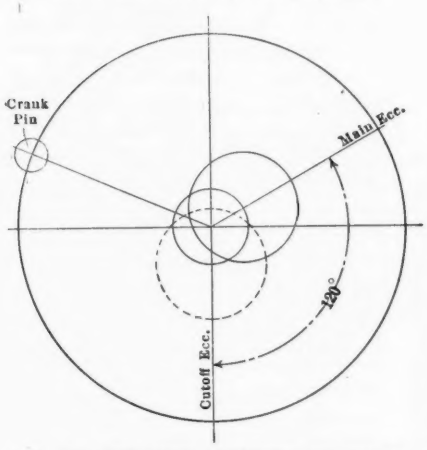


FIG. 20. RELATIVE POSITIONS OF CRANK, MAIN AND CUTOFF ECCENTRICS

at the head end of the cylinder so that its ports are lined up with the ports in the head-end steam valve as shown in Fig. 8. Rotate the engine until both eccentrics stand with the center of their throw toward the cylinder and locate the crank-end cutoff valve in a similar manner, bearing in mind that the outside ports of the steam valves are covered by the outside edges of the cutoff valves. The next step is to locate the cutoff eccentric in relation to the main eccentric.

Place the crank again on the dead center, say the one nearest to the cylinder. Now turn the engine in the direction it should run until the crosshead has traveled ¾ inch. Turn the cutoff eccentric over until the cutoff valve at the head end of the cylinder just closes the ports of the steam valve at that end. Move the governor weights out to their extreme outer position, care being taken not to disturb the position of the cutoff eccentric, and secure the weights to the cutoff sleeve by means of the clamp provided for that purpose. The relative positions of the crank, main eccentric and cutoff eccentric, if the engine runs over, will be as shown in Fig. 20. Turn the sleeve so that the weights are in their extreme inner position, and if the cutoff eccentric and valves have been properly located, the ports of the steam valve at that end will not be covered by the cutoff valves. Turn the engine again until the crosshead is in the same position at the other end of the stroke. Throw the weights out as before and if necessary adjust the cutoff at the crank end of the cylinder so that it just closes the ports of the steam valves. A slight readjustment of the valves may be necessary after an indicator card is taken.

A sufficient number of weights should be added to the bell crank to bring the engine to the required speed. The purpose of the spring on the bell crank is to give steadiness to the governor, and just sufficient tension should be given it to keep the governor from hunting.

To change the direction of rotation of the engine, the governor weights must be disconnected and reversed. The case is provided with two holes for the fulcrum pins at the ends of the weights for the new position of the weights. The valve setting will have to be entirely changed to suit the opposite direction of rotation.

Use and Abuse of Follower Bolts

By W. H. Wakeman

An engineer was sent to a distant city by a prominent engine-building firm to erect one of their large horizontal cross-compound engines. While he was assembling the parts he twisted off one of the follower bolts by bringing too much leverage to bear on it. Removing the broken stub he inserted another and broke that in the same way. Not daunted by this experience he put in another and caused it to share the same fate. The fourth victim was screwed in and practically twisted off like its predecessors, but it was down into position, and owing to the fact that the material was not completely severed, the head remained in place. The engineer sent to the shop for three more bolts, succeeded in getting them in, all other parts were assembled and the engine was started.

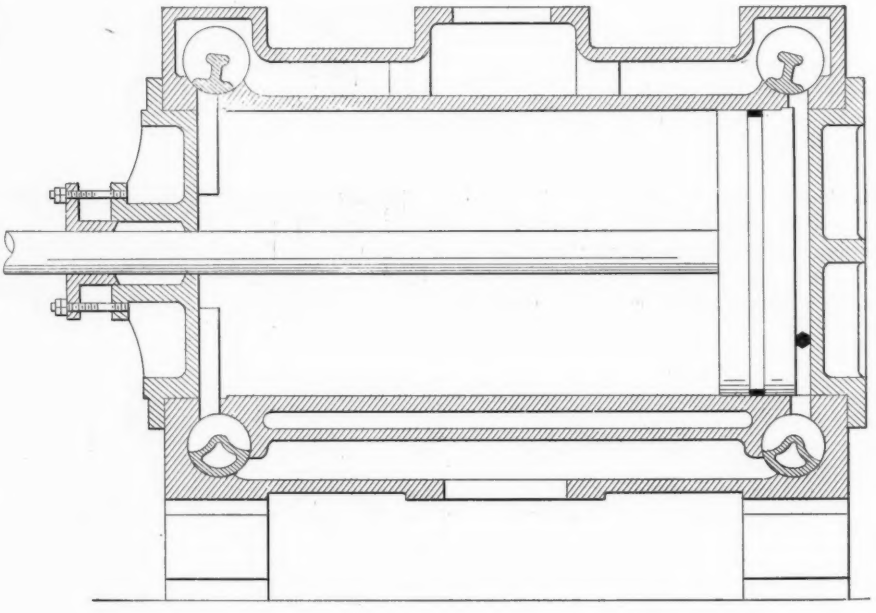


FIG. 1. SHOWING WHERE BOLT HEAD LODGED

After the engine had been in service a short time, the head of the bolt that really was broken when put in, but did not fall apart at that time, came off and, while falling toward the bottom of the cylinder, was caught between the head and the piston, as illustrated in Fig. 1. This shows that it stopped at a thin part of the head, and due consideration of the momentum of the heavy parts as shown, also of the very great leverage exerted by the crank

due to its position near the inside center, makes it plain that something was broken before that piston began to move in the opposite direction. The cylinder head proved to be the weaker part; consequently, the bolt head was forced through between two webs as shown in Fig. 2, although the hole is made comparatively larger than it was originally.

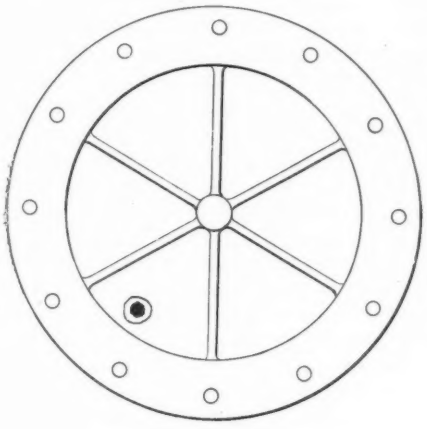


FIG. 2

The head was removed, taken to a machine shop and the ragged hole bored round. It was tapped with a 3-inch pipe tap, a plug screwed in and in 1½ hours the engine was in service again.

There are several lessons to be learned from this incident. Of course, the follower bolts ought to have been a better fit in the threads made to receive them, but taking this condition as actually found the erecting engineer should have discovered the imperfection before he twisted off the first bolt, because they ought always to be loose enough to screw down into place without using a leverage of more than 12 inches, which is sufficient to force a bolt down properly, if it is a good fit, yet is not enough to spoil it if only a tight fit has been provided.

Having destroyed one bolt by applying too much force, there certainly was no excuse for repeating the operation once, while the repetition of it twice causing the failure of a third bolt under the same conditions shows that experience is not always a competent teacher, although failure of a scholar to comprehend the lesson presented is not always to be charged against the instructor. If we take into account the fracture of the fourth bolt, which was really accomplished the same day, the evidence of poor judgment is greater still, but this was not demonstrated until a later period.

A Defective Bolt Discovered in Time

The first engine that I had charge of was fitted with Dunbar packing rings and a follower plate held in place by four bolts. I took these out one day for cleaning and examination, and while replacing the bolts I twisted one of them until it was practically broken in two, but having a well developed sense of feeling, even while lifting on a wrench, I was aware of the fracture, or crack, before the parts became entirely separated; consequently, I not only instantly ceased turning the bolt head, but was able to turn the whole bolt backward, thus removing the lower part of it without further trouble. This was a defective bolt, as the leverage was not sufficient to ruin a sound one.

A socket wrench with a square, straight handle was made for these bolts, and I always used a monkey wrench of a certain size on this square handle, as shown in Fig. 3, which is a plan of the cylinder and piston. From this handle to the place where force was applied by hand was 10 inches. For about 30 years I have used a similar wrench on various engines, and have not increased the leverage mentioned. Having never fractured another follower bolt, nor had one work loose in practice during this time, it is good evidence that the rule adopted is practical and safe to follow.

Intelligent Application of the Wrench Requisite

A little practice in connection with intelligent application of the wrench used, and due observation of results secured will enable any engineer to avoid much of the trouble and worry that we frequently hear of along this line. For illustration, when screwing in a follower bolt, it is not difficult to decide whether it is binding in the threads, or if it is going in loosely until the head strikes the follower plate. In the former case it ought to be taken out and a suitable tap turned into the hole, or, if this is not practicable, a die may be used to cut the threads down until the bolt will fit tight but still will go in until the head holds as it was intended to. If these tools are not at hand, and a lathe is not available, the bolt ought to be put in and taken out several times, as it will go easier every time. If a litle dust from the grindstone trough is put on the threads it will assist in shortening the time required to make a good fit. Personal experience has taught me that such jobs are frequently done by the light of a tallow dip, or a smoking petticoat oil lamp, in the very early morning, after many weary hours of labor on repair work; therefore, the tendency is to be less careful than under better conditions. If a follower bolt is too tight it may still have sufficient torsional strength to be forced into place without fracture, but remember that the action of steam tends to fasten it more securely in place, and the time will surely come when somebody will have to take it out. Due consideration of the "golden rule" and the possibility of having to remove it yourself should be sufficient to prevent leaving it in bad condition.

If the bolts are too small there is usually but one remedy, which is to put them in and get the engine started on time, but measurements ought to be taken and new bolts made without delay. Put them in place, not the first chance that is presented to find the engine dismantled for some other purpose, but make an opportunity in the very near future.

In any case where five or more follower bolts are used in a piston, it will do no harm to leave one out for a day to be used as a model by which to make new ones that are a snug fit in a hole in a piece of cast iron tapped out for the purpose, into which the old bolt is a loose fit. Of course, it is better to use micrometer calipers if they are available, but having completed many such jobs in a satisfactory manner with only common and inexpensive tools, it seems appropriate to make suggestions along this line for the benefit of others. Although expensive tools are now available for making repairs in my plant, there is pleasure sometimes in using less advanced methods where good results are secured, and I am free to admit that in some cases the work is done in less time than a more scientific but less practical machinist would require.

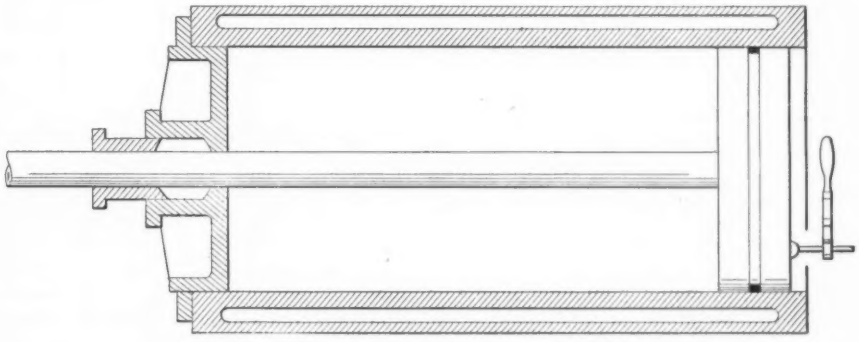


FIG. 3. SHOWING APPLICATION OF WRENCHES

It is not necessary to follow the example of a certain engineer who fractured one of his follower bolts while making repairs, and would not start his engine until a new one was made, although he had four good ones to depend on. The shop was shut down for about one-half day on account of his decision in the matter, causing the loss of many dollars.

Blowing the Works Whistle Automatically

Interesting Description of an Arrangement for Doing This, without Depending upon the Human Element, Except to Wind the Clock

BY FRANK SAWFORD

There are probably very few works of any pretensions without a steam whistle for giving the signal to start or quit work, as the case may be; ranging from the small shrieker for the little shop, to the deep-toned chime whistle for the large works. In most cases the whistle is left to the care of the watchman or fireman, who pulls a string at the appointed time, and very often the only guide he has to rely on for indicating the appointed time is a pocket timepiece of greater or less reliability.

It is thought the following description of an arrangement for blowing the whistle automatically, and dispensing with the human element entirely, except so far as is necessary to wind and check the clock, will be found useful in many works. The arrangement consists of four principal parts: the whistle, the magnet for blowing it, the relay for closing the circuit and the clock.

The clock may be of any pattern desired, but should preferably be of the regulator type, with a pendulum beating seconds, and should be capable of keeping time to within five seconds per week. An additional wheel is required in the clock movement making one revolution in 24 hours, and also a circuit-closing arrangement to operate the relay. The relay in turn closes the power circuit and operates the whistle magnet. The clock should be placed in a suitable position, where it will be free from vibration and where it can be readily checked and corrected. The office is the best place.

The relay may be near the clock or the whistle magnet, as may be desired, the only connections required being a pair of wires from the clock and another pair to the magnet. The magnet should be placed as near to the whistle as possible, and connected to the whistle valve by a small flexible steel wire or chain.

The whistle will, of course, need to be above the roof of the boiler house, and steam should always be left on right up to the valve, the valve being attached to the whistle, and the bottom of the pipe should be drained to insure dry steam. The whistle will then respond promptly when operated. If there is much pipe exposed to the open air above the roof of the boiler house, it is preferable to have the pipe well lagged with nonconducting composition, for, if it is left bare, it is quite possible that considerably more steam will be condensed than will be used by the whistle.

The Clock

Referring to the sketches and taking in hand the clock first, Fig. 1 shows an outline of the circuit-closing device fitted to the movement, *A* being the minute hand, *B* the hour hand. On the minute-hand arbor is fixed the double cam *C* on which rest two ⅛-inch diameter steel rods *D*. These rods are fitted into little hard-rubber blocks *E* which insulate the rods from the clock frame, and from each other. The rods are held by small pinching screws in the rubber blocks. A piece of

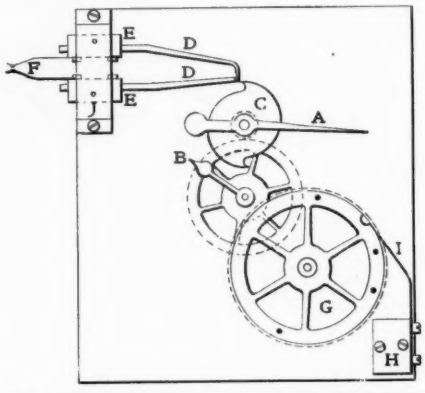


FIG. 1. CIRCUIT-CLOSING DEVICE FITTED TO CLOCK MOVEMENT

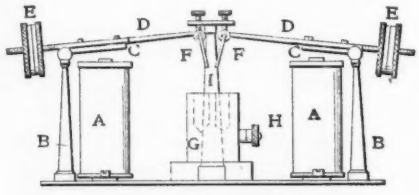


FIG. 2. THE RELAY

steel rod, shouldered at each end to form pivots, is fitted tightly into each rubber block at right angles to the steel rods *D*, and insulated from them. The complete rods are mounted in the brass frame *J*, which supports the pivots at the front end, the rear-end pivot being supported by the clock plate. At *F* are shown the contact springs, of phosphor bronze about 0.005 inch thick, with small platinum tips at the outer ends, the inner ends being secured to the hard-rubber blocks by two small screws. The action of this arrangement will be apparent. Upon the cam *C* advancing, the lower of the two rods *D* falls, bringing the bronze spring *F* into contact, and closing the circuit. The circuit is again broken when the upper rod falls.

The duration of contact may be made as long as desired by adjusting the distance between the ends of the rods *D*. The ends of the rods *D* which rest on the cam *C* should be bent at right angles, so as to lie across the cam, and both the tips of the cam and the ends of the rods should be filed square to knife edges to allow the rods to fall clear and also to permit a close adjustment. If nicely fitted, the duration of contact may be made as short as five seconds if desired. This make and break will take place every half hour.

Another contact-making device is necessary to complete the circuit at the times when it is desired to blow the whistle. On the arbor of the hour hand *B* is fitted a pinion meshing into a wheel *G*, which should have a ratio of 2 to 1, wheel *G* thus making one revolution in 24 hours. If wheel *G* has 48 teeth and the pinion on *B* 24 teeth, each tooth on *G* will correspond to half hours. This will be found very convenient for locating the contact pins, which are of brass about 1/16 inch in diameter by 3/16 inch long, riveted into the rim of the wheel *G*. The positions of the contact pins on the wheel rim may easily be found by dividing the rim into 24 parts corresponding to 24 hours and fitting the pins at the times it is desired to blow the whistle. At *H* a hard-rubber block is secured to the clock frame. This rubber block carries a phosphor-bronze spring *I*, which makes contact with the brass pins in wheel *G*. It is not necessary to have a platinum tip on this spring, as, owing to the revolution of wheel *G*, a rubbing contact is obtained and the pressure of the spring may be made comparatively heavy, the thickness being preferably about 0.025 inch.

The action of these two contacts is as follows: Contact is made by cam *C* every half hour, and the duration of this contact is made as long as it is desired to blow the whistle. This half-hour contact is connected in series with the contacts on wheel *G* and spring *I*, and current cannot flow until both contacts are made, and it is interrupted when either contact is broken.

Thus the whistle blows at the times determined by the pins on *G*, and for a length of time as determined by *C*. If it is desired to blow a code call, this could easily be arranged for

by providing a suitable cam at *C*. The rest of the clock may be of ordinary first-class construction and calls for no description beyond that previously given.

The Relay

The relay, Fig. 2, which is operated by the clock circuit-closing device, and which in turn operates the whistle magnet, should be capable of being operated by about six ordinary dry cells, and should have magnets and contacts in duplicate, to eliminate the chances of failure as much as possible. The type shown in Fig. 2 was adopted by the writer and proved very satisfactory. As may be seen it is extremely simple. The magnet spools *A* are 1 inch in diameter by 2 inches high, and wound with No. 28 Brown & Sharpe silk-covered copper wire, the cores being ⅜-inch diameter soft steel, with hard-rubber washers fitted tight at each end

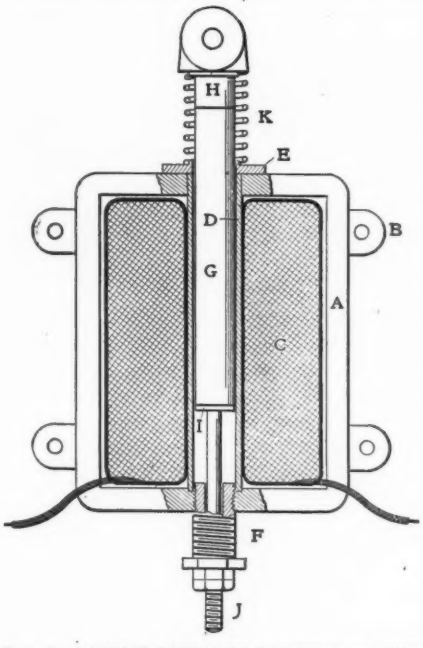


FIG. 3. SECTION THROUGH WHISTLE MAGNET

to form the spool. The soft-steel cores are riveted to a yoke of similar material 1 inch wide by ⅛ inch thick. The complete magnets are secured to a brass baseplate by screws through the yoke. The armatures *C* are of the same size and material as the yokes, and are mounted above the magnets *A* on brass edges, which fit loosely into holes drilled in the top end of *B*. Across the armatures and at right angles to them are secured brass rods *D*, ⅛ inch square, the outer ends being turned and screwed to carry the adjustable counterweights *E*, and the inner ends carrying the forked pieces *F*. These forks are simply small pieces of No. 14 Brown & Sharpe gage copper wire fitted through hard-rubber bushings in the ends of the rods *D*, the ends of the forks pointing downward. At *G* are shown two mercury cups. These cups are brass blocks secured to a hard-rubber base and have two ⅜-inch holes drilled in the upper end of each to contain the mercury, and a terminal *H* for connection to the circuit.

At *I* is a brass pillar carrying a cross piece on top with two small adjusting screws, as shown. Normally the ends of the rods carrying the forks *F* are held up against the adjusting screws by the counterweights *E*, the hight of these adjusting screws determining the distance between the forks and the mercury cups, and also the distance between the armatures and the poles of the magnets. The distance between the forks and the mercury cups should not be less than ⅜ inch, and not more than ¼ inch between the armatures and the poles of the magnets. Any desired adjustment within these limits may be made by means of the counterweights *E* and the adjusting screws on *I*.

The two pairs of magnets *A* are connected in parallel to the wires from the clock, and the mercury cups *G* to the whistle circuit. When the clock circuit is closed, the magnets *A* pull the forks *F* into the mercury cups *G*, which closes the whistle-magnet circuit, and upon the clock circuit being again opened the counterweights *E* pull the forks out of the mercury cups up to the screws on *I*. The counterweights should be adjusted so as to pull the forks up smartly, but not heavy enough to prevent the magnets operating the forks. A drop of oil should be floated on top of the mercury in the cups *G* to prevent oxidation by the arc formed on breaking the whistle-magnet circuit. All of the various parts are mounted on a brass baseplate of suitable size, and should be fitted into a dust-proof box with glass top and sides.

Whistle Magnet

This is of the solenoid type and is shown in section in Fig. 3. At *A* is the magnet yoke which is a rectangular forging and has four lugs *B* attached for mounting. The coil *C* is fitted into the yoke *A* and is wound on a wooden former about 1¼ inches in diameter with No. 20 Brown & Sharpe silk-covered copper wire, and the completed coil should measure about 4 inches in diameter by 6 inches long. The former is removed after winding, and the coil completely covered by linen tape wound lengthwise through the hole and round the outside, and then varnished. Short pieces of flexible lamp cord should be soldered to the ends of the winding to facilitate connection to the circuit. The coil is held in position within the yoke by a brass tube *D* which should be a moderately tight fit inside the coil.

The brass tube is secured by a brass plate *E*, screwed to *A* by two small screws, the bottom end of the tube *D* being let into a recess 1/16 inch deep in the yoke *A*. At *F* is an adjustable plug with a check nut screwed into the yoke *A* and entering into the tube *D*. The soft-steel plunger *G* has a brass head *H* screwed and pinned into the top end, the bottom end having a brass washer *I* soldered thereto. A short piece of ⅜-inch brass rod *J* is also screwed tight into the bottom end of the plunger, this rod passing loosely through the plug *F* and having two nuts as shown. The brass spiral compression spring *K* holds the plunger up in its highest position, that is, with the nuts on *J* resting against *F*. Upon the coil *C* being energized, the plunger *G* is pulled downward against the tension of spring *K* until the washer *I* strikes *F*. The function of this washer is to prevent the plunger sticking to plug *F* by the residual magnetism retained in the magnetic circuit, thus insuring a prompt return of the plunger when the coil is de-energized.

The stroke of the plunger may be varied by adjusting the nuts on rod *J*, and the most effective pull of the plunger is found by adjusting plug *F*. A hole is drilled through the top end of *H* for

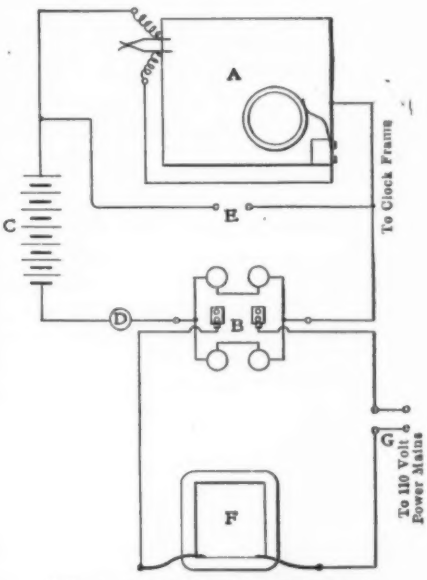


FIG. 4. DIAGRAM OF CONNECTIONS

attaching the cords or chain leading to the whistle valve. Care must be taken that the cord leads straight in line with the center line of the plunger to allow it to work freely, otherwise sufficient side strain might be put on the plunger to prevent its working. The plunger should be 15/16 inch in diameter, and the bore of the brass tube 1 inch.

The whistle calls for no special description beyond that already given, except that the valve should operate freely, and the cord should be led from the whistle lever at the most effective angle. The magnet is powerful enough to operate any size of whistle which can be operated by hand. The larger sizes of whistle usually have a small pilot valve to operate the main valve.

Electrical Connections

Fig. 4 shows a diagram of connections, *A* being the clock, *B* the relay and *C* a

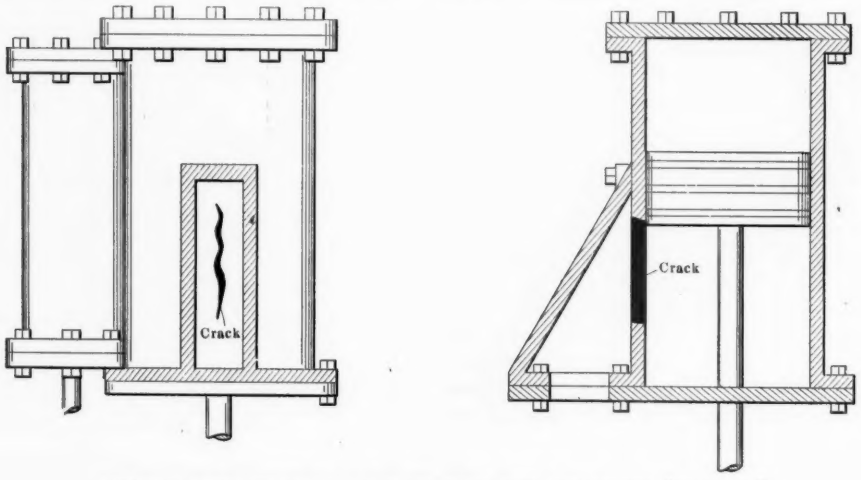
six-cell battery of ordinary dry cells; *D* is a single-pole switch for cutting out the relays when it is desired to stop the whistle; *E* is a pair of terminals which may be used to connect to a fire-alarm system, or to a push button; *F* is the whistle magnet, and *G* a double-pole switch for connection to the power circuit.

The magnet as described is suitable for connection to a direct-current circuit of 110 volts. For any other voltage the winding of the coil may be modified accordingly. This apparatus may appear somewhat elaborate from this description, but it may be said that a similar rig has been in use for many years, and has never been known to fail, and moreover has had practically no attention beyond winding and adjusting the clock.

A Split Cylinder on the Steamship "St. Paul"

The fact that the American line steamship "St. Paul" arrived at New York two days late upon a recent trip was attributed by the press to stress of weather, but was partly due to a cracked high-pressure cylinder.

Steam was reported coming in considerable quantities from the high-pressure gland of the port engine and a shutdown was ordered. An examination showed that the steam was not coming from the gland, but from an opening in the bottom of a bracket, as shown in the accompanying sketch. The bracket was hollow, and a crack, which was open 1/16 of an inch and 2½ feet long, connected its interior with that of the cylinder.



SHOWING THE CRACK IN A CYLINDER ON THE STEAMSHIP "ST. PAUL"

The high-pressure cylinder was cut out by blocking the piston valve in the mid-position and admitting the steam directly to the first intermediate receiver. The revolutions were cut down on this engine to 66 per minute, but the full speed of 86 revolutions was kept up upon the starboard engine. Some six hours was occupied in making the repairs. The piston rings in the high-pressure piston were found broken, and one of them jammed over another in the same slot.

Catechism of Electricity

923. *If the commutator is eccentric or too rough to be smoothed evenly by means of a file, what should be done with it?*

It should be turned down in a lathe. If the armature is large and difficult to remove from the machine, a portable lathe or truing device can be attached directly to the shaft of the armature as shown in Fig. 282, and the commutator turned down without removing the armature from the motor. The armature should be held stationary and the device revolved around the commutator by hand, using the shaft as a bearing. The tool is moved across the commutator by a screw feed actuated by a detent clamped to the shaft.

If the armature is small and easy to remove from the machine, it should be placed in an ordinary stationary lathe and the commutator turned down in the usual manner.

924. *In case it becomes necessary to remove the commutator from the armature, how should this be done?*

The simple device shown in Fig. 283 is convenient for this purpose. It consists of two pieces of iron *c* and *c*, shaped to fit back of the collar *b* on the commutator spider. Through holes in the ends of *c* and *c* are passed bolts *e* and *e*, and over the outer ends of the bolts is slipped the bar *f* which bears against the shaft *d*. Before commencing to remove the commutator it is necessary to have all the wires disconnected from it. By screwing up the nuts *g* and *g*, the spider and commutator will be drawn off. After producing the first strain on the bolts, however, it may be necessary to give the commutator a light rap to start it.

925. *What characteristic features are present when the sparking is caused by weak field magnets?*

The speed of the motor will be unusually high with weak field magnets unless the magnetism is very low or lacking altogether, in which case the motor will run very slow, stop or perhaps run backward. If the pole pieces are tested by holding a piece of soft iron near them there will be little if any attraction.

926. *How may the trouble be definitely located?*

Place wooden chips under the brushes so they do not come in contact with the commutator, and with the field rheostat short-circuited, close the field coils upon the supply circuit. If upon opening this circuit there is no spark there is a broken wire or connection somewhere in the circuit. If there is a spark the circuit is not broken, but one of the magnet coils may be short-circuited. This may be determined by testing with a piece of soft iron which when held between the pole piece of the short-circuited coil and the adjacent pole piece will be attracted to the latter, but not to the former. Another method of testing for a short-circuited field coil consists in passing a current through the field circuit and measuring the drops of potential across the different coils. A short-circuited coil will show little or no drop in comparison with

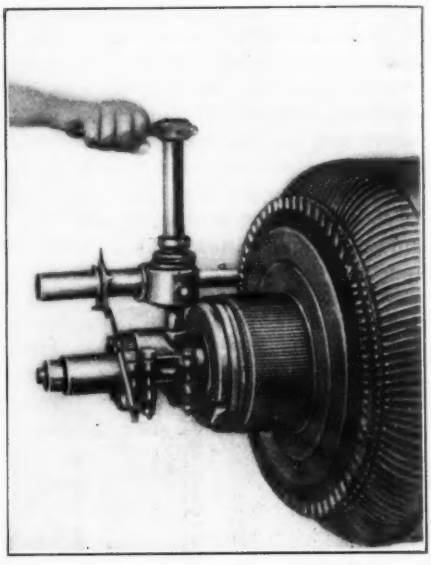


FIG. 282. COMMUTATOR-TRUING DEVICE MOUNTED ON THE ARMATURE SHAFT AND OPERATED BY HAND

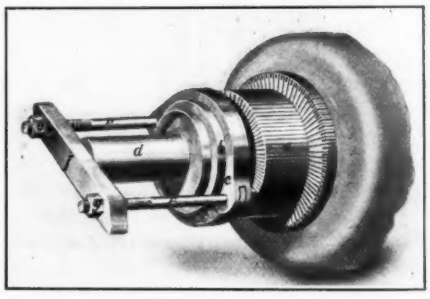


FIG. 283. SIMPLE DEVICE FOR REMOVING THE COMMUTATOR FROM THE ARMATURE

the others. A short-circuited coil may be caused by its wire being grounded at two points on the frame.

One of the field coils may be reversed, producing a weak field. This can be determined by passing a current through the field circuit and moving a compass needle from one pole piece to the other in succession. The needle will reverse its direction at each succeeding pole if none of the coils is reversed.

Condenser and Back Pressures in Refrigerating Plants

By F. E. Matthews

How does a refrigerating engineer know when the condenser pressure and back pressure of his plant are right for most economical operation? What are the proper pressures?

In general, with an engineer who is familiar with the underlying principles on which the efficiency of refrigerating systems depends, it is largely a matter of judgment. Such judgment must be based on knowledge of the temperature of the condenser water, whether there is sufficient condenser surface for the compressor and whether or not the condenser pipes are free from uncondensable foreign gases. With these things known to be right, condenser pressure for different temperatures of cooling water should be approximately as follows:

1 gallon per minute per ton per 24 hours—							
Temperature of cooling water, degrees F	60	65	70	75	80	85	90
Condenser pressure, gage, lb	183	200	220	235	255	280	300
Temperature of condensed liquid ammonia, degrees F	95	100	105	110	115	120	125
2 gallons per minute per ton per 24 hours—							
Condenser pressure, gage, lb	130	153	168	183	200	220	235
Temperature of condensed liquid ammonia, degrees F	77	85	90	93	100	105	110
3 gallons per minute per ton per 24 hours—							
Condenser pressure, gage, lb	125	140	155	170	185	200	215
Temperature of condensed liquid ammonia, degrees F	75	85	90	93	95	100	105

Similarly, the evaporating or back pressure within the expansion coils of a refrigerating system depend upon the temperatures on the outside of such coils, i.e., the air or brine to be cooled. For average practice back pressures for the production of required temperatures should be approximately as follows:

Temperature of room, degrees F	10	15	20	28	32	36	40	50	60
Back pressure, gage, lb	7	10	12	15	22	25	27	30	35	40
Temperature of ammonia, degrees F	13	10	5	0	8	12	4	17	22	26

In every event the condenser pressure should be kept as low as possible and the back pressure as high as possible, narrow limits between such pressures being as important to the efficiency of a refrigerating system as wide ones are to that of a steam engine in which the economy increases with the range between boiler pressure and condenser pressure.

The full importance of this truth is seldom recognized by either the operating or the supervising engineer, and neither strives for the last pound of increased back pressure half so diligently as for the last inch of vacuum in the steam condensers, although the pressure is of relatively far more importance than the latter in its effect on the general efficiency and economy of the plant.

As regards both condenser and back pressure, the limit that should be striven toward, but which, of course, can never be reached, and produce work, is when the pressures in the condenser and expansion coils, respectively, are such that the corresponding liquid temperatures are the same as that of the condenser cooling water and the cold-storage brine temperature, respectively, to be produced.

Atmospheric ammonia condensers employed in temperate climates where cooling water of from 55 to 70 degrees Fahrenheit is available usually contain about the square feet of heat radiating surface per ton, and as indicated in the first table, are cooled by from one to three gallons of water per minute per ton per twenty-four hours.

Not only does the amount of cooling water required per ton vary with its temperature, but also with the cooler temperatures required and the condensing pressure encountered.

If, for example, a cooler is to be maintained at 20 degrees Fahrenheit, a back pressure of 15 pounds is to be carried, resulting in 0 degree ammonia within the expansion coils, and the head pressure be 145 pounds, only 0.75 gallon of cooling water will be required, provided it be sufficiently cool to rise 20 degrees in temperature and still be 10 degrees cooler than the temperature of the condensed ammonia corresponding to the pressure. Now, the temperature corresponding to 145 pounds head pressure is 82 degrees Fahrenheit, so that 82 — 30 = 52 degrees, the required temperature of the cooling water.

Where there is only one temperature to be produced in the cold-storage compartments a back pressure is usually carried, such that the temperature corresponding to that pressure will be about 22 degrees Fahrenheit below that of the cooler temperature. Under average operating conditions the cost of the amount of expansion pipe required to allow of this range in temperatures balances up fairly well with the loss in efficiency that would be encountered if less expansion piping were installed and a lower back pressure carried.

Where several different temperatures are to be maintained with one back pressure no fixed rule can be followed and each individual case must be figured out separately. If only a small per cent. of the total cooling work be low temperature, it is usually advisable to reduce the temperature range between the liquid ammonia and the surrounding air making up for the reduced range by the installation of inversely proportionately more pipe. In this case the expenditure of an abnormal amount of pipe in a small per cent. of the entire duty allows of an increase in efficiency of the entire plant.

While the necessity of producing a low temperature in a single box reduces the efficiency of the entire plant—or that part of it which is required to carry the low back pressure because of that low temperature—there is a slight compensation for the decreased efficiency in the way of decreased first cost of expansion piping for the higher temperature boxes. The ammonia pressure and temperature being reduced in order to cool the low temperature box may be sufficiently colder than the high-temperature boxes as to allow the pipe surface in the high-temperature boxes to be reduced often as much as 50 per cent. This condition would obtain when the difference between the ammonia and the high-temperature boxes becomes 44 degrees Fahrenheit.

In general, the engineer should endeavor so to manipulate his expansion valves as to carry the highest back pressure possible and still produce sufficient refrigeration in his coldest coolers. The limit to possibilities in this direction is when no more ammonia feed can be put on the expansion coils without causing liquid ammonia to return to the compressor, causing it to pound and the ammonia-rod stuffing boxes to leak.

The back pressure can be carried materially higher and the efficiency of the plant can be materially increased by keeping the expansion coils free from the insulating effect of ice on the outside and oil on the inside. Opportunity should be taken to remove the oil from the expansion coils every two or three seasons at most, and oftener if a considerable oil is thought to have worked into the system.

If the engineer is always on the alert he can often find opportunity to shut his machine down for a few hours sufficiently often to allow the ice to melt off the expansion coils, not only allowing the system to operate more economically when it is running but also to save a considerable number of hours operation without disarranging temperatures and consequently materially reducing the operating expense of the plant.

Do not reduce the refrigerating effect of your system by closing down expansion valves, reducing the back pressure, and literally throwing away power because the refrigeration is not needed. Where the duty of the various boxes will admit, push them hard until they are a little colder than required, then shut down the machine. You will be surprised at the saving that can be effected.

Inaccuracies Due to Drum Motion Distortion

A Practical Analysis of This Cause of Errors in Indicator Diagrams, with Results of Tests to Determine Their Magnitude in Various Cases

BY JULIAN C. SMALLWOOD*

Everyone who has considered the subject is aware that that exceedingly useful device, the indicator diagram, is full of errors. The straight-line motion of the indicator and the apparatus for reducing the motion of the engine crosshead may be faulty in principle or workmanship, or both. The indicator spring rarely records steam pressures truly and the drum motion does not, by any means, accurately correspond with that of the crosshead. Of these four sources of error, however, the first three are under control and, if they exist, constant. Thus, a high degree of excellence in workmanship may render negligible any errors in the duplicating and straight-line motions when their design is correct. Indicator springs may be accurately calibrated and compensation made for their error. But inaccuracies due to drum-motion distortion are neither constant for different conditions of speed nor easily determined for particular ones. Therefore these inaccuracies are worthy of special attention. It is the purpose of this article to make an analysis of them and to present the results of tests made to determine their magnitude under different conditions.

It is well first to consider the cycle of events in the nature of an indicator and the forces controlling it. Fig. 1 represents a plan section of a drum, the string of which is attached to the pin of a device to reduce the movement of the crosshead of an engine to the length of the indicator diagram to be taken. The pin is shown at the head-end dead center in full and the dotted figure represents the other end of its stroke. The spring is shown by the spiral, one end of which is fastened to the drum, the other to the axis upon which the drum oscillates. Beginning at the head-end dead center there is a certain pull in the cord which is resisted by the spring tension T_h at this point. As the crosshead moves to the left, this tension will increase in a rate proportional to the extension of the spring, becoming maximum, T_c, when the drum has revolved as far as it will go in a clockwise direction. Thus the average value of the spring tension is $(T_h - T_c) \div 2$. The work done by this force is expended in overcoming the kinetic energy of the drum. This latter varies as the square of the drum's speed. Now, the motion of the crosshead is approximately harmonic and therefore the velocity of the drum is zero at the extreme positions of its travel and maximum in its mid-position. These forces are represented in Fig. 1 by the arrows. It is obvious that the least distortion will ensue when the maximum value of K (or the force of acceleration at mid-stroke) is just balanced by an average drum-spring tension.

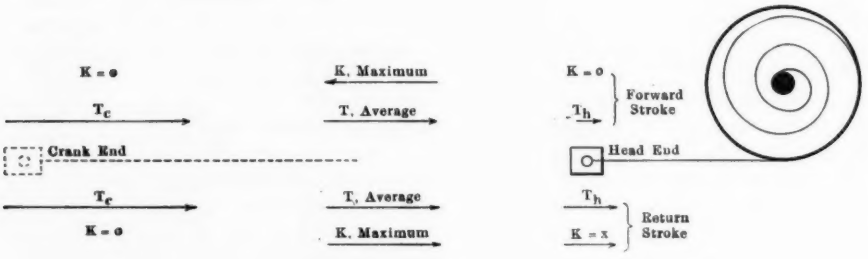


FIG. 1

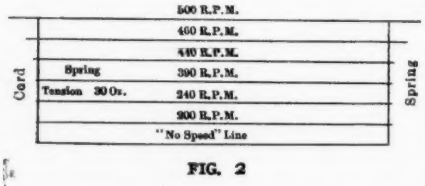


FIG. 2

Considering, now, the reverse motion, it is seen that the spring tension is the only force acting and that it is maximum at the crank-end dead center and diminishes in the same way as it has increased. This force imparts kinetic energy to the drum which stores part of it until the end of the cycle, when it is delivered in an effort to stretch the cord. The tension T_h also operates to do the same.

In the foregoing discussion no attempt has been made to point out the inaccuracies of the drum motion between its limits, the object being to determine the deformation only at the ends of the stroke. It will be seen that this is dependent upon five quantities, namely, the spring tension, the revolutions per minute, the elasticity of the cord, the mass of the drum and the length of the diagram, the first and last of which may be conveniently varied to suit any particular conditions. Further, the deformation at the crank end will be produced by an abnormal stretch of the spring, while that at the head end will be permitted by the elasticity of the cord. The former may be expected approximately to vary directly as the mass of the drum, length of diagram and square of the revolutions per minute, and inversely as the spring tension. Similarly the latter will vary directly as the spring tension and the elasticity of the cord.

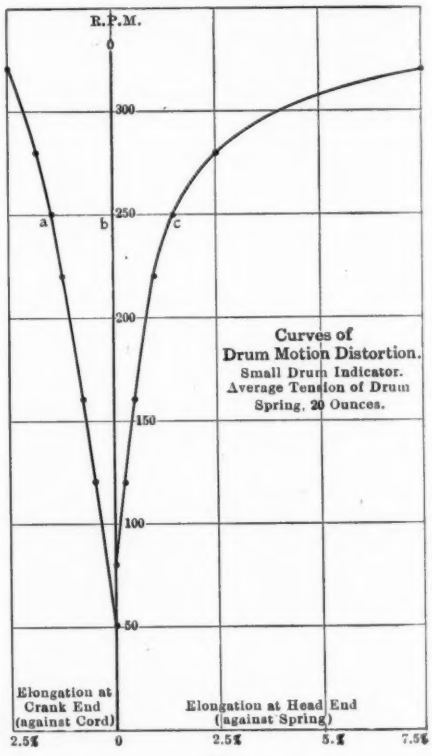


FIG. 3

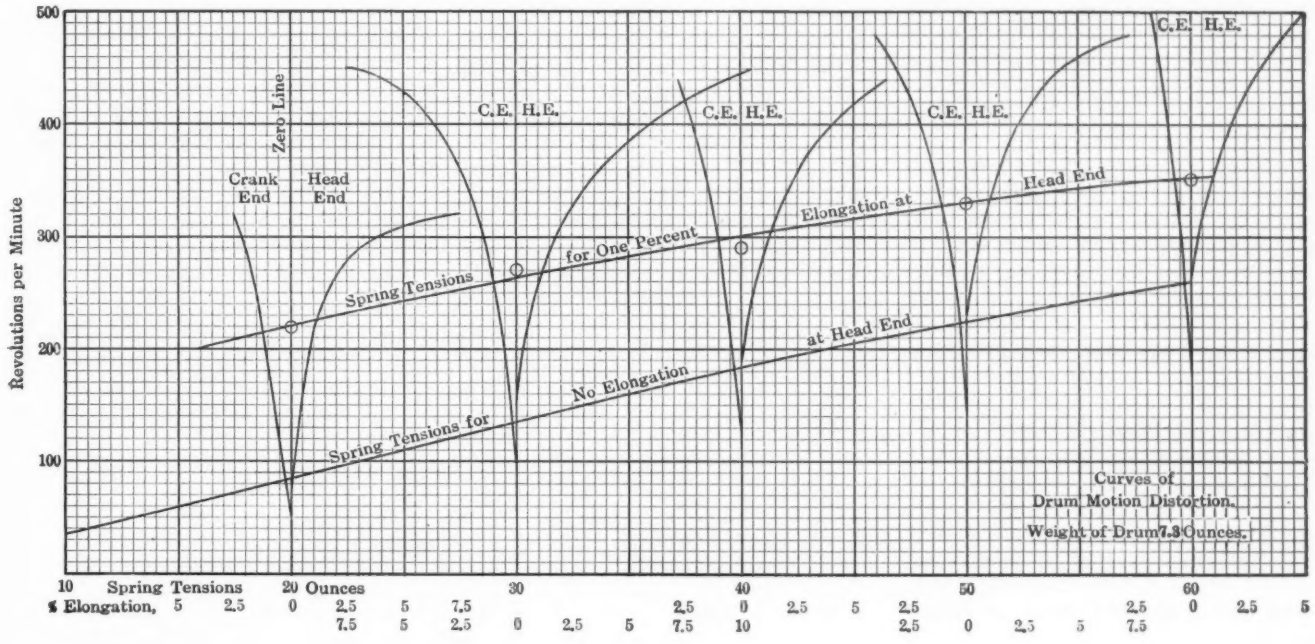
To Minimize Drum-motion Distortion

It follows from the above considerations that to reduce drum-motion distortion to its minimum it is necessary to have the mass of the drum as small as possible, the

*Instructor in mechanical engineering at the University of Pennsylvania.

cord as nearly nonelastic and as short as may be and the reducing motion such as to give the smallest diagram that will be convenient to use. Further, and more important, the spring tension should be adapted to the speed of the engine to be indicated, so that its average value just balances the force of acceleration of the drum in its mid-stroke and is no greater; for, if it is greater, the effect will be to increase the deformation due to the stretch of the cord.

With these considerations in mind an attempt was made to measure by tests the magnitude of the deformations produced by drum-motion distortion. The results of these tests are presented by the curves accompanying this article. Two indicators, whose drums were of different weights, were used. They were connected to a crosshead of 4 inches stroke which derived its motion from a small motor supplied with a heavy flywheel to obtain uniformity of rotation. Speeds were varied through fine graduations by changing the motor resistances and braking the crank shaft. Determinations at various spring tensions were made, each set being begun by making two vertical lines with the indicator pencil at the ends of the "no-speed line." In this way overtravel at each end could be determined, care being taken to keep the diagram in one position on the drum for each run. Fig. 2 shows one of the diagrams taken. The results were plotted as shown in Fig. 3, where horizontal distances represent percentages of elongation laid out to either side of the vertical zero line, and vertical distances represent revolutions per minute. This diagram, representing the action of the


Revolutions per Minute
500
400
300
200
100
Zero Line
Crank End
Head End
C.E. H.E.
C.E. H.E.
C.E. H.E.
C.E. H.E.
Elongation at Head End for One Percent
Spring Tensions
No Elongation at Head End
Spring Tensions for
Curves of Drum Motion Distortion.
Weight of Drum 7.3 Ounces.
10 Spring Tensions 20 Ounces 30 40 50 60
% Elongation, 5 2.5 0 2.5 5 7.5 2.5 0 2.5 5 2.5 2.5 0 2.5 5
7.5 5 2.5 0 2.5 5 7.5 10 2.5 0 2.5 5 7.5

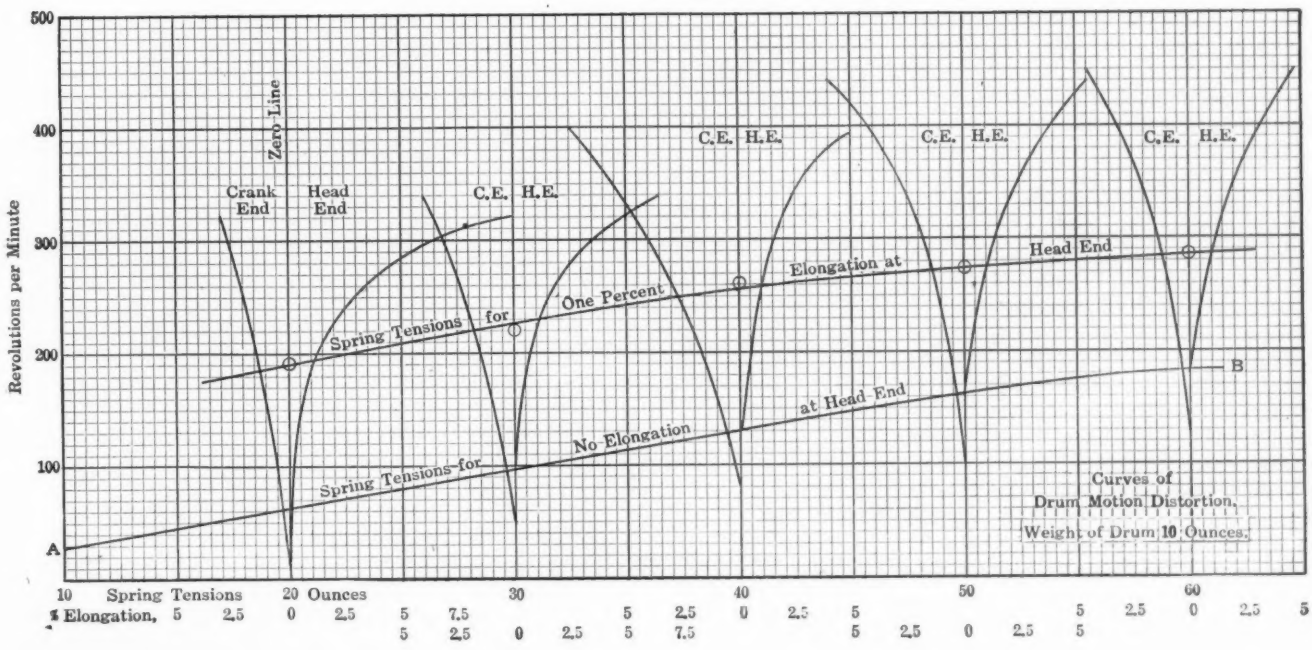


FIG. 4

lighter of the two drums tested with an average spring tension of 20 ounces, shows that up to 50 revolutions per minute the drum follows the reduced motion of the crosshead very closely, but that above this speed the distortion at the crank end, against the stretch of the cord becomes measurable and increases rapidly with increasing speed. The elongation on the head end against the tension of the spring does not begin until a speed of 80 revolutions is reached. At 250 revolutions the elongation at the head end is equal to $a\,b$, and on the crank end to $b\,c$, each equal to about 1½ per cent. At a little above 300 revolutions the fling is sufficient to throw the drum against the stops on the head end and no increase of speed would be practicable at this drum tension.

Diagrams Made with Different Spring Tensions

In Fig. 4 a number of such diagrams made with different average spring tensions are grouped upon the same chart for each of the two drums. The points at which distortion begins upon the head end are formed by the curve $A\,B$, which represents, therefore, the number of revolutions per minute at which overtravel at the head end commences for any particular spring tension. Another curve is drawn through the points at which head-end elongation is 1 per cent. Overtravel at the crank end is ignored, since it is permitted by the stretch of the indicator cord which is in turn dependent upon its length and texture. It would therefore be impracticable to apply a general rule for setting the drum spring for this end.

The weight of the moving parts of the heavier indicator drum was found to be about 37 per cent. greater than that of the lighter.

The indicator cord used in the tests was 2 feet long. Although of very good quality, it showed in a preliminary test a stretch of 0.05 of an inch per foot per pound dead weight, and this after it had been previously stressed.

Inspection of the curves may astonish some engineers who are accustomed to place unquestioned reliance upon the truth of indicator diagrams. The inaccuracies shown, however, may easily be verified by a simple trial. It appears that deformation begins with comparatively low speeds and that the speed corresponding to the beginning of deformation increases with the increase of spring tension. With low spring tensions the deformations become enormous at high speeds. It will be noticed, too (considering the curves for the lighter indicator), that though the deformations at the two ends of a diagram are nearly equal immediately after the critical speed has been reached, beyond this the elongation due to overtravel against spring tension becomes greater in a progressive ratio. This is as would be expected since the cord is limited in its elasticity, while the spring is not. The difference is not so marked in the curves for the heavier indicator, but this is probably due to the fact that higher spring tensions here are needed to overcome the inertia of a greater mass. Thus, upon the return stroke both T_h and K have a greater value than would obtain in the small drum, and the cord stretches accordingly. And, finally, it may be observed that the head-end elongation varies approximately as the square of the speed, that the crank end varies at a somewhat lower rate and that the head-end elongation at constant speed varies nearly inversely as the spring tension.

Consider, now, the error introduced into an indicator diagram by the inaccuracy of the drum motion. Fig. 5 represents a diagram which has 3 per cent. elongation at one end and 1 per cent. at the other. An inspection of the curves will show that this amount of distortion may ordinarily be met with. The mean ordinates obtained from the distorted and correct diagrams are 1.06 and 1.03 inches, respectively; that is, an error of about 3 per cent. In measuring the cutoff from such a diagram it will readily be seen that the error may be still greater. In some cases, however, the error due to increased area of the indicator diagram may be offset by the increased base length, so as to make the error in the mean hight negligible.

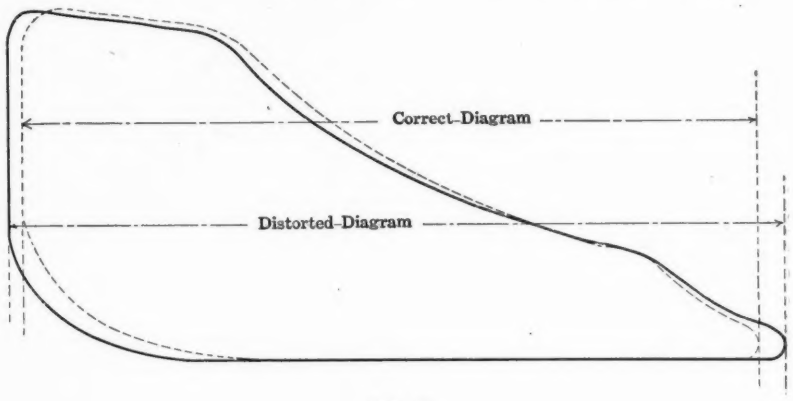


FIG. 5

Deformation at Mid-stroke

Hitherto nothing has been said concerning the amount of deformation in mid-stroke. This is difficult to determine and requires special apparatus, but it is hoped that a presentment of the subject may be made at some later time. For the present purpose, however, it will be sufficient to make the following observations:

Starting from the head-end dead center the tension of the spring is small, while the opposing force due to the velocity of the drum is zero. Hence no appreciable distortion can result since the stretch of the cord is small. If this initial stress could be maintained in the cord the drum's motion would be an exact duplicate of that of the crosshead. According to the best setting of the drum spring as previously determined there will be, however, no stress in the cord at mid-stroke. Beyond this the work done by the spring increasingly exceeds the kinetic energy of the drum and therefore the pull in the cord will increase and deformation due to its stretch will increase up to the end of the stroke. Upon the return stroke the tension in the string is diminishing up to the end of the crosshead's travel. It is thus seen that under the best conditions there is a varying stress in the cord throughout a complete motion of the drum and we may therefore expect distortion of the diagram in all its parts, and the farther the stress in the cord departs from a uniform one the greater will be the inaccuracy. Obviously if the spring tension at mid-stroke is greater or less than is necessary to overcome the effect of inertia at this point this departure will be more marked.

The results and considerations presented lead to the conclusion that a perfect indicator diagram correctly representing the relation of pressure to piston position cannot be made with a spring-actuated drum, because of the inaccuracies introduced by drum-motion distortion. These inaccuracies may be reduced to the minimum by using piano wire instead of cord, as short as possible in length, and by properly adapting the spring tension to the speed of the engine to be indicated.

Allowing for Errors

The following simple procedure is suggested to allow for errors when accurate determinations are desired: Before putting in the indicator spring when indicating an engine two vertical lines may be drawn to correspond to the ends of its stroke. These are perpendiculars at the extremities of a "no-speed line;" that is, a line drawn by turning the flywheel at such slow speed that no effect of inertia is produced. Leaving this card on the drum, if the engine is now run at the various speeds at which it is to be indicated and horizontals drawn at these speeds, the elongation will be shown by the distances of the ends of such lines from the neighboring verticals. The cor-

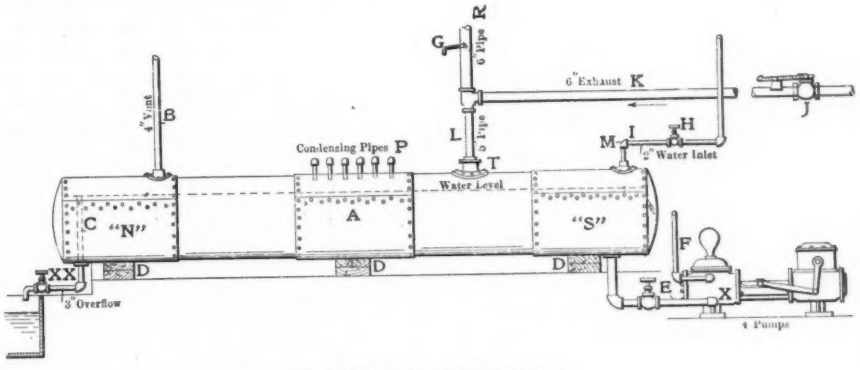
rections may then be made after the engine has been indicated. These corrections, of course, involve only the elongation of the diagram and do not consider deformations at mid-stroke, but the former is very likely the more considerable.

It is suggested that the device for tightening the spring of an indicator be marked in such a way that the tension of the spring may be adjusted for any desired amount without actual measurement. This may be simply accomplished by first measuring with a spring scale the tension at the limits of the drum travel for each adjustment and marking with a series of lines the locking device to correspond. From the curves presented in this article the indicator may then be conveniently adjusted for any particular test so that the least error results.

Reservoir Moved by Internal Forces

By J. O. Frazier

A few years ago the writer had an exciting experience with an old boiler which was used for the collection of water from the heating coils in a sugar house. The boiler was 36 inches in diameter and 60 feet long, and when nearly full of water was moved endwise about 1 foot from an internal conflict of exhaust steam and water. An unusual combination of circumstances was necessary to produce the results brought about, whose remote probability of simultaneous occurrence, as well as the necessities of rush work in connection with other machinery, had perhaps been the reason why the matter had not received more serious consideration, and some means provided for their accommodation. The action of the contributing elements will best be understood by reference to the sketch.



RESERVOIR AND CONNECTIONS

In this illustration, *A* represents the reservoir, which many years before had served as a plantation boiler, when plain cylinder boilers without any flues were the prevailing type on the plantations. This reservoir received all the condensed steam from the evaporating apparatus of the house, which entered through the pipes *P*. There was a 5-inch exhaust-steam connection *L*, which served to admit a small portion of such surplus exhaust steam as might exist at any time into the reservoir, from which all the boiler pumps received their supply. Another outlet, which then existed on the other side of the house, gave relief to the greater portion of the exhaust.

In putting up a double-effect evaporating apparatus the preceding year, the system had been piped to the new apparatus. Considering it was to run nearly all the time (and when it didn't run there were presumably few of the pumps or engines running) and to prevent the expense and time of changing the pipes *K* and *R*, which were only 6 inches in diameter, they were left as the sole outlet for such surplus of exhaust as might exist at any time. There were about 300 engine horsepower in the house and about 20 steam pumps, with steam cylinders ranging from 16 down to 5 inches in diameter, so it will be seen that the size of the pipe depended upon to carry off the surplus was out of all proportion to the sizes of the engines and pumps. It is a usual condition in such houses that when the double-effect evaporator, which generally consumes all the exhaust steam, is not running but few of the machines are in operation, and thus the strong probability that the pipe would never be called upon to relieve more than a small portion of the total supply. So the larger pipe system which served the evaporator, some of it of 8-inch and 10-inch pipe, was just piped through the relief valve *J*, which was loaded to carry a pressure of 5 pounds in the exhaust system for supplying the exhaust-steam evaporating apparatus; and thus give final relief to a presumably small discharge, the other outlet having been plugged.

The homemade butterfly valve, shown in pipe *R* at *G* had been put in years before to deflect exhaust, which then could never be considerable in amount, into the reservoir, for its value in mingling with the boiler-feed water. There were a vent pipe *B*, 4 inches in diameter, to prevent there ever being any pressure in the heater, as they called the reservoir, a 3-inch overflow pipe *C* and a 2-inch water inlet *I*, to supply such additional cold water as might be necessary to make up the boiler supply. There were four boiler pumps feeding from the reservoir, all coupled about as the one shown at *X*. The reservoir was resting on wide wooden blocking *D* only a few inches from the ground.

While making the rounds one day and while in front of the boilers, behind which the reservoir was located, the writer heard and felt a commotion of unfamiliar sounds and it took several seconds before these sounds could be located behind the boilers in the neighborhood of the reservoir. Rushing around to this point a sight met the gaze which will not grow dim for a long time to come. There was that heavy reservoir of water, which could not weigh much less than 15 tons, actually launching, first in the direction of *N*, then in a few seconds, with a greater movement, toward *S*. There was surely too much steam from somewhere, and the only possible source was the evaporator. Upon investigation it was found that the evaporator had been shut off, and the steam of the whole house, which was in full blast, had been turned toward the heater. The first move was to raise the weight on the relief valve *J* and turn the steam back into the evaporator.

Back in the boiler room the commotion had subsided; the heater was there, or nearly there, but what havoc among the piping. Suction pipes of all four pumps, as at *E*, were broken and all the hot water was running out of the reservoir over the floor. All boiler-feeding apparatus was disabled, and there were 13 boilers with a working head of steam. Well, the fires were all covered with dirt, ashes, water and anything else that would smother a fire; then began a rush for chain tongs, pipe fittings and all the paraphernalia of a hurry-up job, and by pressing everybody and everything into service, and with considerable good luck, which once in a while comes the engineer's way, the plant was running again in about three hours with many makeshifts in the way of pipe fittings. It is well to explain that in these houses very hot feed water is so universally used that the possibilities of independent feeds with an injector is never thought of and is practically unknown in the sugar house.

Even with the disaster which was wrought to the piping, there was on the whole less damage done than would be expected from such a commotion. The pipes *R* and *B* extended up through an old iron roof and did not suffer; overflow *C* was broken near *X X* and also the elbow *M* on the cold-water inlet. All the smaller pipes connected with the reservoir had enough spring in their makeup to escape.

As to the combination which brought about the trouble and the action of the conflicting forces, the man who operated the evaporator was new at the business

and had not learned how to keep the apparatus working by feeding water when the supply ran short. He threw the relief valve *J* open and the steam, endeavoring to get out through an opening far too small at best, found the butterfly valve, which had not been shut for a long time, closed and consequently deflected all the steam down into the reservoir on top of the water. When the commotion began the water tender put more water on at the supply pipe *I*, which would quite naturally make matters worse. First, the volume of steam coming in through *L* would force the water to the end *N* and plug up the vent *B*, which under the circumstances would be of little service. Then the flood of cold water coming in at *I* would so condense the steam as to create a lower pressure at the end *S*, which would cause the water to surge back toward that end, to be followed by an accumulated pressure sending it back toward *N*.

It would be hard to form an accurate idea of how long this action continued, but judging from circumstances perhaps from five to eight minutes. During this period it was evident that the reservoir was acted upon in alternating directions, with a period of about ten seconds each way, that it launched toward *N* about 1½ inches, then about twice that amount toward *S*, making a total gain toward *S* of 14 inches before the commotion was over. Among the provisions made for the prevention of a possible repetition of the trouble, at least in such violent form, was a sheet-iron flange, with only a 1-inch hole for drainage between the flange *T* and the reservoir. The butterfly valve *G* was taken out altogether.

Experiments on Gas Producers

By W. H. Booth

In a recent paper read before the British Iron and Steel Institute by W. A. Boru, some interesting facts relating to producer gas were made known. These had to do very largely with gas as produced for furnace work to which the regenerative principle is applied, and the experiments bear upon the use of water vapor in the air fed to the producer. The argument put forward by the authors, for R. V. Wheeler collaborated in the work, was that it was not advisable to put more steam into the air blast than corresponded with a saturation temperature of 60 degrees Centigrade; that is to say, assuming air at 60 degrees Centigrade to be saturated with water vapor that amount of water vapor would be the ratio of steam to be supplied. With any higher ratio of steam the thermal efficiency falls and the gas becomes less suited for furnace work. Experiments showed that with even less ratios of steam better results were obtained in rapidity of gasification and high efficiency.

With a 60-degree Centigrade saturation temperature a producer rated to consume 16 hundredweight per hour (1792 pounds) was successfully worked at 24 hundredweight (2688 pounds) with a fuel depth of 42 inches.

The saturation temperature was successively lowered to 55, 50 and 45 degrees Centigrade, with the result as between 60 and 45 degrees that the average coal consumption (night and day) rose from 17.5 to 18.4 hundredweight per hour; the CO_2 produced fell from 5.10 to 2.35 per cent., the carbon monoxide rose from 27.3 to 31.6 per cent.; and the hydrogen fell from 15.5 to 11.60 per cent., methane remaining the same at 3.05 per cent. and nitrogen rising from 49.05 to 51.40 per cent.

The total combustible gas increased from 45.85 to 46.20 per cent., and its calorific value from 178.7 units per cubic foot to 180 gross, and from 166.9 net units to 170.5, the yield of gas per ton falling from 135,000 to 133,700 cubic feet. The steam consumption per pound of fuel was diminished from 0.454 to 0.2 pound, and while in the first case only 76 per cent. of the steam was decomposed, all was decomposed at the 45-degree Centigrade test. The ratios of the oxygen from the steam and from the air were 0.44 and 0.33, respectively, and the efficiency ratios 0.725 and 0.73. Thus the efficiency was practically the same.

As to the use of gas in furnace work, the authors state that their previous convictions as to the greater suitability of carbon monoxide have been confirmed and they emphasize the importance of carbon monoxide for steel melting or reheating furnaces.

Needless to say, where hot gas is being supplied direct from a producer to a furnace it is important that as high a percentage as possible of the steam should be decomposed, or otherwise there must be loss of excessive cooling without additional calorific capacity of the gas produced. The reactions in a producer are probably very complex. The general reactions expressed by $C + 2\,OH_2 = CO_2 + 2\,H_2$ comes more and more into play as compared with the reaction $C + OH_2 = CO + H_2$, when more and more steam is added; so that the equilibrium point of the reversible reaction $CO + OH_2 = CO_2 + H_2$ becomes shifted more and more to the right, as does also the reversible reaction $2\,CO = C + CO_2$. In one test the raising of the steam saturation temperature from 45 to 80 degrees Centigrade increased the carbon dioxide sixfold; doubled the hydrogen and halved the carbon monoxide. This question of equilibrium is one of the phenomena of mass action which deserves greater study than perhaps practical men have yet accorded it. This is especially so with regenerative working, for action and reaction occur in the gas during its passage through the regenerator. Equilibrium of any gaseous mixture, such as one of hydrogen, steam, carbon monoxide and carbon dioxide, is dependent upon the relative proportions of the gases and upon their temperature. At any given temperature the state of equilibrium is defined by the expression

$$\frac{CO \times H_2O}{CO_2 \times H_2} = K,$$

the product of the concentrations of the monoxide and the steam being a definite ratio to the product of the concentrations of carbon dioxide and hydrogen.

Hahn showed by experiment that for temperatures of 1086 to 1205 degrees Centigrade, which fairly correspond with the temperatures in the hottest parts of a regenerator, *K* varies between 1.95 and 2.10, so that practically we may assume *K* equals 2.0. Any mixed gas of the above order passing through a regenerator which has a higher limit of temperature of about the above figure will tend to arrange or rearrange its dynamic equilibrium until the above equation is fulfilled with the value of 2 for *K*; and the tendency will be the greater when the initial ratio is most removed from $K = 2.0$, for the stress tending to rearrangement will be greater. It is therefore useless to start with a gas too rich in CO_2 and H, for equilibrium will tend to produce $CO + H_2O$. A producer gas heated to 1100 degrees Centigrade will attain equilibrium with $CO_2 = 10.2$, $CO = 20.6$ and $H_2 = 18.0$, and was found to do so when it contained initially the above three gases in the ratios 17.8, 10.5 and 24.8.

The authors do not express any dogmatic opinions, but base their arguments on the assumption of the correctness of Hahn's formula for *K* and consider that this should be further investigated in order to prove or disprove its correctness. Incidentally the thought arises that the reactions within the cylinder of a gas engine are probably extremely complex, consisting of an innumerable rapid series of changes of equilibrium in the mass of the burning gas. But such violent reactions only make their joint effect felt as an integrated result in the shape of fairly even pressure, for the waves which appear on an indicator diagram and often form the subject of much speculative writing do not seem to live when the indicator spring is changed for a stiffer one of less movement.

The presentation of further experimental data in regard to superheated steam will be looked forward to with great interest, but what we now need is a thorough review of the properties of saturated steam. At present our knowledge of the heat required above saturation is probably more accurate than what we know about saturated steam.—Prof. R. C. H. Heck.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Governor Link Arm Caused Trouble

Our company bought a 16 and 25 by 4-inch cross-compound engine. The governor was of the type shown in Fig. 1. This engine was belted to a 175-kilowatt generator and was operated at a speed of 250 revolutions per minute. It was concluded to make a direct-connected outfit of it, so a new subbase and field frame and an outboard bearing for the armature shaft were made. The flywheel was removed and a flanged coupling used to couple the crank and armature shafts together. In testing, the load was obtained through a water rheostat. When everything was ready, the engine was started, and when the speed got up to about 100 revolutions per minute the governor began to hunt, the speed running from 100 to 300 revolutions per minute, and then down again and so on. The engine was shut down and after several trials and many examinations the trouble was located. What made it more difficult was the fact that with a load the engine ran all right. I finally removed the cover plate *E*, Figs. 1 and 2, and found the eccentric strap *F* pulled back at the top, causing the cover plate to bind against the eccentric at *A*, and the strap against the eccentric at *B*, Fig. 2. I slacked off the springs and pulled the strap square on the eccentric, after placing three paper liners, each 0.01 inch thick, between *E* and *F*, Fig. 2.

I next removed all tension from the springs *S*, put more tension on springs *S'* and started up the engine; although it governed well the speed was only 160 revolutions per minute. I shut down the engine, took off the springs, disconnected the link *L* and placed the eccentric strap square on the eccentric. When I tried to put the link *L* back into the slot of the weight *W* I found the link was 3/16 inch out of line with the weight arm, so it had to be sprung into place (see the dotted lines in Fig. 2). When the tension was removed from the springs *S* there was so much play in the pins that the link would not bind, but when both springs were tightened they pulled the weight arm to its true center and held it there, and the link *L* had to be sprung into the slot in the weight, pulling the eccentric strap with it.

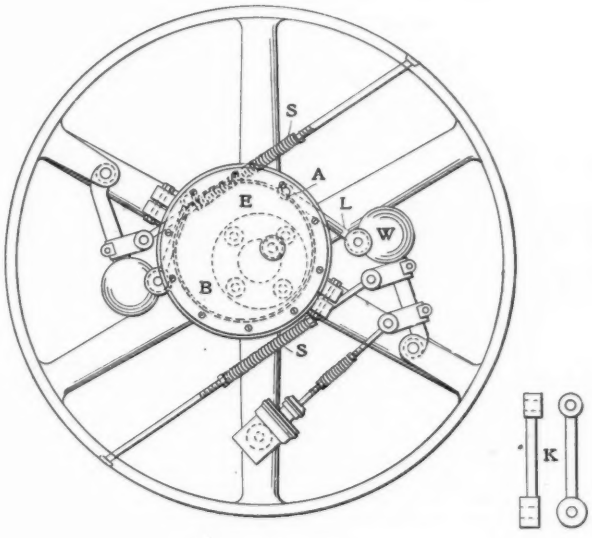


FIG. 1

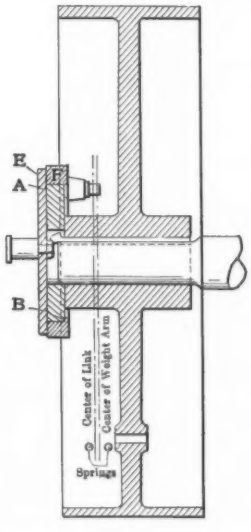


FIG. 2

I had a new link made with a 3/16-inch offset, as shown at *K*. The engine is governed very nicely by that means.

The superintendent could not see how it was that the engine had not given any trouble before. The reason is that it was belted to a large generator and had enough load to keep it steady, and there never was any time when the load was all off at once.

A. DAHLIN.

Chicago, Ill.

Induction Motor Operates as a Generator

Recently the local electric-light and power company installed a 20-horsepower induction motor to run in multiple with a water wheel. The mill where this was done is situated on a small stream furnishing about 20 horsepower at full head, but is at the present time giving about 15 horsepower, which is not enough to run the mill.

The power company offered to put the motor in for a two months' trial, charging only for the current used during that time; but if the installation proved successful, the owner was to pay for the motor and installation, and a minimum bill of $2 per horsepower per month, the usual charge being $1. A smaller motor would have taken care of the installation, but would not have run the plant at times of low water.

The motor acts as a governor to the water wheel, which is without such a device, the speed running up and down, depending upon the rate of feed of work to the machines. The motor is left on continuously and with the garnet machine running alone acts as a generator, supplying power to the feed line and running the meter backward. If the picker is thrown on, the meter immediately starts forward and the speed drops about 2 per cent., the motor running slightly above synchronous speed as a generator and below as a motor, but as this made a variation of speed of nearly 30 per cent. without the motor, it is considered more than satisfactory. With the garnet machine running alone the meter runs sometimes backward, sometimes forward, depending upon the flow of water to the wheel. The wheel gate is set to take the full flow of the stream, thus getting the entire benefit of the head.

This arrangement has been running one month, continuously, day and night except Sundays. It has turned out about 1200 pounds of shoddy a day, while before it turned out only 500 per day of 24 hours.

It has used 520 kilowatt-hours, which sells at six cents, making $31.20 for the month, or less than the minimum charged.

The owner is satisfied and will accept the motor, as he could not get this service with a steam engine, and he is already planning to run his garnet machine at a higher speed in order to get full benefit of the minimum bill.

The electric company is satisfied, as the customer runs his picker at non-peak hours and is helping them out at peak-load hours to a small extent.

JOSEPH B. CRANE.

Broadalbin, N. Y.

Hygrometry

Referring to W. Vincent Treeby's comments on Mr. Hart's contribution on hygrometry which appeared in the issue of January 5, Mr. Treeby says that when we state that steam is saturated we intend to convey the idea that it is saturated with heat units. The word "saturation" applied to any physical material is usually taken to mean that it is saturated or contains all of a given substance that it is possible to hold without losing any. For instance, in the case of a salt solution, brine is saturated when it contains or dissolves all of the salt possible without precipitation.

I believe that the word "saturation" when used in connection with steam is more or less a misnomer and does not convey a true meaning in this sense. By "saturated steam" I understand that the steam is generated and is held in contact with water. It certainly is not saturated with heat because heat can be added indefinitely, thereby producing superheated steam, except that it is in another sense saturated with heat units, or it contains as many heat units as it will contain while in contact with the water.

Technically, to my mind, it is saturated with water; that is, dry steam contains all the water it will hold without precipitation if it remains in a quiescent state.

C. W. C. CLARKE.

New York City.

Sea Water Caused Foaming

At one plant where I was employed we dug a well near a river in which salt water flowed. The soil was loose-sand gravel and the well was dug 12 feet below the river level at low water. We used 8x8-inch timber cut so as to form a hexagon curb 14 feet across, each tier of curb being 1 inch smaller on each side than the one below, thus forming a bell-shaped curbing. The ends were cut to fit, and were spiked at the corners and toe-nailed at the sides. The weight of earth on the outside assisted in pushing the curb down.

We dug out about a foot below the curb all around and six men standing on the curb, each with a piece of timber, gave a few blows all together on top of the curb to drive it down.

The well worked all right until a dry spell came and our supply of fresh water for the well, which came from the hills, failed, and we were soon pumping brackish water into our boilers.

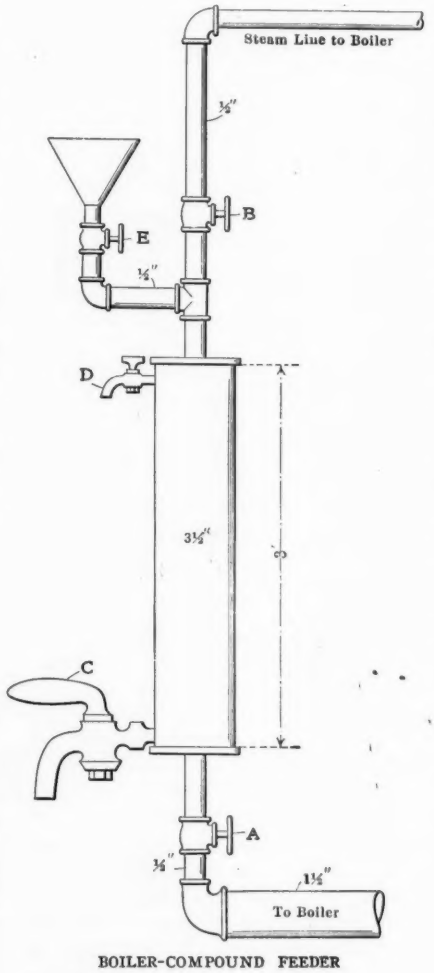
Dutch ovens were used, and when one was fired a little harder than the other that boiler would get busy passing water into the engine, and in five minutes there would be no water in the water glass. The engine, a 24x30-inch, was usually flooded to a standstill, or nearly so. When this happened we deadened the fire as quickly as possible, and after again getting the boiler filled to its proper level, it was put to work. This kind of trouble continued until the end of the summer.

D. F. BEDFORD.

Brantford, Can.

Compound Feeder

Referring to the illustration, it will be seen that this feeder operates with condensed steam. It is made from a piece of 3½-inch pipe, 3 feet long, with the ends capped, the caps being tapped for a ½-inch pipe. It can be placed in any convenient part of the boiler room, preferably near the feed pipe and always below the water line in the boiler, the lower end being connected to the feed pipe between the check valve and the boiler with a ½-inch pipe.



BOILER-COMPOUND FEEDER

The condenser pipe leading from the upper end to the dome or steam space should be about 6 feet high above the water level in the boiler. To fill, close the valves *A* and *B*, open the drain and air cocks *C* and *D*, and, after draining, close the drain cock *C* and fill by means of the funnel through the valve *E*.

By making the solution extra strong it is not necessary entirely to fill the body of the feeder, as it will finish filling with clear water from the feed pipe by slightly opening the valve *A*. When full, close the air cock *D*, open the valve *B*, and the feeder will operate, its rate of feed being regulated by the valve *A*.

GEORGE RUSSELL.

Spring City, Tenn.

High Water Level

This question of the proper hight of water in boilers is too often left to the fireman, who cannot, in many instances, tell how far below the gage the tubes are located.

A maker of boiler-feed regulators experimented as to the proper hight of water for economical steaming and found that the result of lowering the water line from three gages down to one gage was not very marked, but when lowered to 2 inches above the tubes a great difference in economy was made. In many localities the law requires the bottom of the gage glass to be placed 2½ inches above the flues, and the fusible plug about the same. So we have in practice at least 5 inches of water over the tubes, with the probability that the water will show at least 6 inches in the glass and more than 8 inches above the tubes.

If the tubes are carried high in the boiler the water line is so high that it is well up to where the cross section is narrow, and provides a small disengaging surface for the steam, causing extra friction and resistance for the steam to rise and separate, which is reflected back and means extra coal consumption. Having the largest space for the easy disengaging of the steam from the water means carrying the water line as low as possible.

It is true that piping will sometimes shake a boiler, but the water line should be carefully looked after in such cases.

In one steam plant feed-water regulators were put in. The old gage columns were left in place and the regulators placed on the side of the boilers. In these regulators the feed valve was held in position by the float, so that the valve was always open, a constant stream entering the boiler. The pressure in the feed pipe operated a pressure regulator on the pump, which was of such design that the only pressure on the metal diaphragm was the difference between boiler pressure and that in the feed pipe. With no more than 5 pounds extra pressure in the feed pipe the pump would supply the boilers with perfect regulation, with the feed valve well open.

The bottoms of the old gages were 4

inches above the flues and the engineer wanted the regulator set to carry 2½ inches of water in the old glass, making 6½ inches of water above the tubes. Carrying the gage half full would bring the water level nearly 10 inches above the tubes.

After awhile the water could not be kept up except by carrying about 30 pounds excess pressure in the feed pipe. As the water came in under the valve the excess pressure tended to raise it and depress the float which had to be more immersed so as to shut off the valve, and this tended to carry the water line higher.

The trouble was that the firemen were afraid to see the water so low in the glass and took measures to fill the boiler up so that it showed a half glass and the engineer partly agreed with them.

The result was that the water was carried 10 or 12 inches above the tubes, with increased cost for coal and increased moisture in the steam.

W. E. CRANE.

Broadalbin, N. Y.

Air Compression Under Difficulties

As an example of what may be expected in air compression when running the compressor with restricted inlet passages or valve opening, the accompanying indicator diagrams, Figs. 1, 2 and 3, should prove of interest to engineers who have compressors in their plants.

In Figs. 1 and 2 are shown normal conditions in the air end of a two-stage, 28 and 17 by 26-inch tandem compressor, connected to a 16 and 30 by 36-inch cross-compound Corliss engine. The first stage compresses to 25 or 26 pounds, and in the high-pressure cylinder the compression is completed to 100 pounds. Recently an accident to the low-pressure side of the engine put that side out of business for twenty-four hours. As it was impossible to get along without air for any length of time, and still keep all parts of the plant in operation, the master mechanic de-

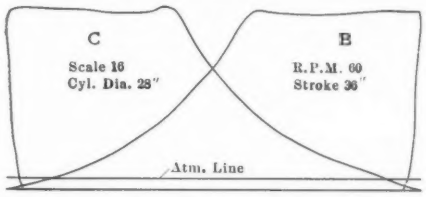


FIG. 1

cided to run the compressor on the high-pressure side alone. This was done in the following manner:

The low-pressure connecting rod was taken off, both steam and exhaust valves taken out and the bonnets replaced; also, the positive-motion air-inlet valves and several of the poppet type of discharge valves on the first stage were taken out. This change allowed free exhaust of steam through the low-pressure steam cylinder, an air inlet, unrestricted as possible, through the low-pressure air cylinder, and an intercooler into the high-pressure cylinder.

When the compressor was started again it took over an hour's running at full speed to get the line pressure up to 80 pounds; whereas, with both sides "hooked up" we could always get the required 100 pounds in 10 minutes. It soon became evident that unless the demand for air was lessened, the pressure could not be raised above 80 pounds, which was about 25 pounds too low to operate some of the pumps and hoists.

After speculating on the interesting question of how much air the compressor was turning out in its one-sided condition, we decided that the trouble lay in the intake resistance to the air, due to taking it at atmospheric pressure (only about 12.5 pounds here) through passages and inlet poppet valves designed for air at 25 pounds.

The master mechanic then decided to get the required line pressure by running a 1-inch bleeder to the third stage of the four-stage high-pressure compressor alongside. The pressures of the different stages

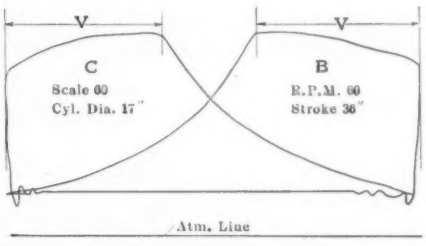


FIG. 2

were 25, 115, 350 and 1000 pounds, and although the second stage would have suited the purpose better, the bleeder was connected to the third stage for reasons of despatch and convenience. A valve was placed in the bleeder to throttle the pressure and, the other end being connected to the discharge line of the crippled compressor, we soon had air enough for the demand. A couple of hours later when the quantity required was greatly reduced, the compressor was able to hold 105 pounds with the bleeder valve closed, and then wishing to see exactly what was doing in that hard-working air cylinder, I put on the indicator and got the diagrams shown in Fig. 3.

As expected, the admission line proved to be almost 7 pounds below atmospheric pressure, as compared with 1.5 pounds on the diagrams shown in Fig. 1. The diagrams also show that the piston actually traveled about one-fourth of the return stroke before getting the pressure back to the intake pressure, as shown at *A*, Fig. 3; and about two-thirds of the stroke before reaching 25 pounds, as shown at *B*, which would be the regular intake pressure under ordinary conditions. By comparing the volumes *V* discharged per stroke, Figs. 2 and 3, it can be readily seen how the capacity was reduced.

Another interesting point is in comparing the compression curves under the different conditions. By plotting out the isothermal curve on Fig. 3, it will be seen that the actual curve gets much nearer to an adiabatic-compression curve than on Fig. 2, thus raising the mean effective

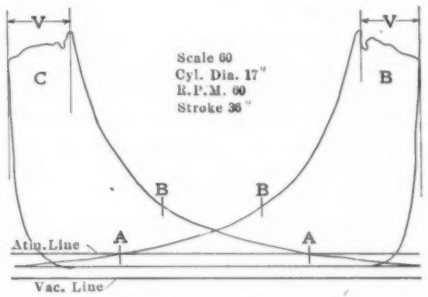


FIG. 3

pressure and hence the power required per unit of free air.

While Fig. 3 represents an extreme case, it goes to show that too much attention cannot be given to air intakes and inlet valves. For example, in making new valve springs to replace broken ones, it is quite possible to make them much stronger than the old ones; or, in the case of positive-motion inlet valves, the point of admission might easily be too late, due to a slipped eccentric, lost motion in reach rods, etc., all of which would necessitate a greater degree of vacuum at the time of admission, and thus throw unnecessary work upon the compressor.

A case in point is that of an engineer who extended his intake flume a few hundred feet out into a bush, to get the screen away from the road dust; and the first fall afterward the screen became clogged with leaves to such an extent that it took a 17-inch vacuum to get anywhere near enough air for the demand.

I have noticed that there seems to be very little practical information on air compression in the bulk of engineers' journals, and if more attention were given to this important branch of our work, I am sure it would prove most acceptable to a large number of us who have compressors included in their plant. More light could easily be shed upon some phases of the work. For instance, I read not long ago the statement of an engineer to the effect that the only function of a receiver on an air line was the same as that of an air chamber on the discharge of a pump. I have always thought two of the most important reasons for a receiver being installed was to provide a place in which to *cool* the air, thus separating most of the contained moisture and allowing it to be blown off; also, to provide a storage place, thus tending to prevent sudden reductions of pressure. What

is the opinion of other readers on this subject?

J. A. CARRUTHERS.

Bankhead, Can.

Criticism of Turbine Installations

I wish to make some comments upon the criticisms by E. H. Lane in the issue of January 5.

Mr. Lane comments upon the small size of the condenser, and also upon what he calls a deficiency in circulating water capacity in the condensing equipment. He states that the American practice is to allow not less than 60 pounds of condensing water per pound of steam; and, further, that the temperature of the water the year round must be considered. His figure of 60 pounds might be all right for New York City and vicinity, but it certainly would be insufficient in Florida and excessive in Labrador.

I will not attempt to answer Mr. Lane's question as to what temperature of circulating water is necessary to maintain the condensed steam at 28½ inches vacuum, as this would depend somewhat upon the design of the condenser.

As regards the size of the condenser, that is, the square feet of cooling surface, Mr. Lane states that the latest American practice is to allow 4 square feet of cooling surface per kilowatt for turbine installations. This was latest American practice in 1904. About 1906 the engineers of the country, and I suppose the manufacturers afterward, awoke to the fact that this rate of surface was excessive, especially in the larger units, and today the standard American practice for large units in temperate latitudes is about 2 square feet per kilowatt maximum rating, or practically half that quoted by Mr. Lane.

Another factor enters into this particular machine which, as I understand it, has a normal rating of only about 7000 kilowatts, the 10,600-kilowatt rating being a periodic maximum.

From the foregoing it will be seen that the ratio of the cooling surface to kilowatts at the normal load is 2.3 to 1, and at the maximum capacity is 1.3 square feet per kilowatt. The condenser provided is very close to the American practice today for large steam turbines. There are a number of 14,000-kilowatt turbines operating today in this country, having a maximum rating of 14,000 kilowatts for 24 hours, which are equipped with condensers containing 25,000 square feet of cooling surface, which maintains a vacuum of 28½ inches under all conditions and which gives a ratio of 1.8 square feet per kilowatt.

There are other machines which have a rating of 9000 kilowatts normal, which are provided with the same condensers. The steam consumption of these big turbines is practically the same as quoted for the Buenos Aires machine.

The reason for the small surface in this condenser not taking into consideration the temperature of water may be due to efficient design. The ordinary condenser as manufactured is far from efficient inasmuch as the steam does not get the best kind of action on the tubes.

I have a case in mind where the condenser surface was reduced about 15 per cent., which resulted in increase in vacuum of over ½ inch. This condenser had a ratio based on normal rating of turbine before changes were made of 3.4 square feet per kilowatt. After the changes were made the ratio was 2.9 square feet per kilowatt on the normal rating basis.

Where salt circulating water is used it is desirable from a maintenance standpoint to have as few tubes in a condenser as possible.

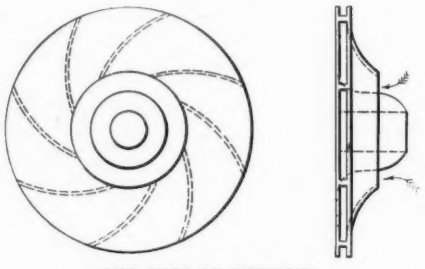
In reference to the installation of electric auxiliaries I can but agree with Mr. Lane that this is apparently a step backward rather than forward.

C. W. C. CLARKE.

New York City.

Centrifugal Pumps

The recent discussion regarding the action of centrifugal pumps has brought



ONE TYPE OF IMPELLER

out some very interesting points. That it takes less power to run one of these pumps with the discharge valve partially or wholly closed is logical, and any operator of this type can easily demonstrate the fact to his own satisfaction, although the exact amount may vary greatly, depending on different details of construction, etc.

In regard to George P. Pearce's criticism of Mr. Kellogg's article, I beg to differ with him, especially where he compares a centrifugal pump to the water brake used by the Westinghouse Machine Company, as described on page 1025 of the June 30, 1908, issue. While the centrifugal pump is built on easy curves, to reduce friction loss to a minimum, the water brake is constructed to give the greatest possible resistance, resulting in the power being quickly transformed into heat. The appearance of the steel impeller and casing, after a few hundred hours' use, gives an idea of the violent impact between the moving parts, while the cast-iron impeller in a centrifugal pump will run month after month at 1000 revolutions or more per minute and not show any particular wear or sign of excessive friction.

The construction of impellers differs with different manufacturers, but in considering the type shown in the accompanying illustration the water, as it enters the center of the impeller, flows through easy bends to the periphery and here, where the velocity and friction are greatest, a smooth, narrow disk is found, which offers a minimum of resistance to the surrounding water. With the discharge closed there is no water flowing from the suction to the impeller and consequently no discharge at the periphery, and the body of water inside the impeller is motionless relative to the impeller, due to the pressure in the casing. The only power required would be that necessary to overcome the friction of this smooth water-filled impeller rubbing against the surrounding water, plus the friction in the bearings, etc. Altogether this friction cannot amount to a great deal and the fact that a turbine pump of this type will run in this condition for several minutes before there is any appreciable increase in the temperature of the water in the casing would tend to prove that such is the case.

R. CEDERBLOM.

Gary, Ind.

Dashpot Does Not Seat

Why will not the head-end dashpot seat when the load is below 300 amperes and the hooks push it down?

The engine is a 30x48-inch Corliss, with seven-eighths cutoff and double eccentrics. The valves open away from the center of the cylinder and have equal travel; the same is true of the wristplates.

By using the starting bar and working the wristplate, the hook engages the catch block with a little clearance and the dashpot seats nicely. Why should it act so?

ELSWORTH DAVIS.

Zanesville, O.

Pumping Hot Water

In regard to C. R. McGahey's article under the above title, in the December 15 issue, I cannot see why it should be any more difficult to pump hot water than cold, if machinery designed for the work is supplied.

I have worked in three different plants, all over 2000 horsepower capacity, each equipped with open-type heaters, and this part of the plant was one of the least of our troubles.

If a plant is equipped with an outside-packed plunger pump, with either brass or good hard-rubber valves, large enough

to handle the necessary volume of water, no trouble will be experienced beyond the ordinary amount of repair work. In two of the plants the pressure on the feed line was maintained by a pump governor, and the water level in the boilers was controlled by automatic feed-water regulators.

A pump should be provided with pet cocks on top of each water cylinder, in order to release air in case of failure of the water supply to the pump.

I have pumped water at 210 degrees and, in case of losing the water in the heater, have used a cold-water line to supply the pump until normal conditions were regained. The only perceptible change shown by the pump was the leakage at the glands, which gradually ceased as soon as the pump began to warm up with the return of hot water.

Occasionally in changing from cold to hot water it became necessary to open the pet cocks to relieve the water cylinder of steam or air, but we were not compelled to stop the pump, as this was only momentary, usually lasting over three or four strokes. In such a system the extra air chamber would be superfluous, and I disagree with Mr. McGahey about using a valve to choke the pump discharge, as this would compel the check valve at the boiler continually to open and close, due to insufficient pressure to hold it open, thus causing undue wear and a certain amount of hammering at this point. It would be better to throttle the pump discharge at the valve between the check and the boiler. I cannot understand why this could not be done with one boiler, the same as with two boilers connected to the feed line.

CHARLES A. CRYTSER.

Windber, Penn.

Cause of Trouble with Oil in Bearings

In the December 8 issue was published a sketch of bearings and shaft supporting a pulley, in which the writer describes a method employed in overcoming an oil trouble, but there was no explanation offered as to the reason why the oil in both outside chambers, in which oil rings were hung, were drained of their contents in the manner described.

Perhaps it is not generally known that in turning journals it is not so much the actual cutting of the metal as getting a clean chip; and an experienced lathe hand knows how to trim his tools in order to obtain a proper finish, thus destroying what would be observed under microscopical examination a complete series of spirals running the entire length of the shaft or journal. I believe that on the journals in question there was a series of spirals, and they naturally influenced the oil as soon as the shaft had bedded itself in the bearings.

It would be interesting to me, and no doubt to other readers, if the correspondent would fill both journals up to the centers, not from one end to the other, plug the holes up that communicate to each of the chambers, and let us know the result of the experiment.

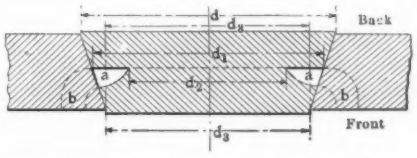
HORATIO W. HUTTON.

Glasgow, Scotland.

Pressure Required to Lift a Check Valve

I read with much interest George P. Pearce's short article on "Requisite Pump Pressure," found on page 970 of the December 8 number, and beg to present the following solution to his problem, together with a short discussion of the drop in pressure on the front or delivery side of check valves:

The forces holding the valve to its seat are the pressure per square inch into the



CONICAL OR PUPPET DOUBLE-SEATED BALANCING VALVE

area of the valve plus the weight of the valve, or in this case:

$$100 \times 1963 + 5 = 1968$$

pounds. The force lifting the valve is the pressure per square inch beneath it into the area upon which that pressure acts. The area of seven 1-inch holes is 5.5 square inches; then

$$1968 = 5.5 \times \textit{pressure}$$

and

$$\textit{pressure} = \frac{1968}{5.5} = 358$$

pounds.

This, of course, assumes that the valve cover makes perfect contact with its seat and prevents the fluid from the delivery side getting between the valve and its seat which requires a perfectly tight-ground point.

It is very evident in this case that if there were a gage placed on both the receiving and delivery sides of the check valve, there would be a drop in pressure after the valve opened from 358 pounds on the delivery side to 100 pounds on that of the receiving side. This would be true only provided that the pressure on the receiving side was due to a column of fluid free to flow out and thus make room for the incoming fluid.

If the pipe conveying the fluid away from the receiving side were small compared with the size of the pipe and storage chamber (say the pump cylinder) on the delivery side of the valve, then the pressure on the receiving side would rise, due to fluid friction in the discharge pipe, while the admission pressure would fall until the two were equalized, and then they would both continue to fall until the pressure at the valve was that due to the static head of fluid on the valve, when the valve would close due to the tendency of the fluid to flow back into the pump cylinders

The trouble here is that the ratio of the area of the admission or delivery side of the valve to the area of the discharge or receiver side is too small.

George H. Anderson is correct in the statement that the total pressure P on the discharge or receiver side (back side) of a check valve is equal to the area of the passage plus the area of the seat multiplied by the pressure per unit area, while the total pressure P_1 on the admission or receiver side (front side) is equal to the area of the passage multiplied by the pressure per unit area. This, of course, assumes a balanced valve; the weight of the valve would increase the pressure on whichever side had to lift it.

The expression "area of the seat" should be modified to read the projected area of the seat on a plane parallel to the plane on which the area of the passage is measured.

Referring to the accompanying drawing, the area of the passage is the area of the circle, whose diameter is d_3, while the area of the seat is equal the area of the annular ring, whose outside diameter is d and whose inside diameter is d_3.

With correctly designed valves and ports having proper ratios of seat area to passage area, there ought not to be variations in pressures which would be perceptible on the ordinary gage.

In this connection it would be interesting to hear from someone who has spent considerable time in the design and operation of valves used for such a class of service.

The drawing shows a diagrammatic sketch of a conical or puppet double-seat valve which may be so proportioned that the pressure on the front side may be equal to that on the back at the moment of opening.

This is accomplished by bringing the fluid in contact with a recess in the valve as shown at *aa*. The fluid is led into this recess through the ports *bb*.

It is evident that if the area of this annular recess, represented by 0.7854 ($d_1^2 - d_2^2$), is equal o the area of the seat, 0.7845 ($d^2 - d_3^2$), the valve will open when the pressure per unit area on the front is equal to the pressure per unit area on the back, since the areas exposed to the action of the fluid pressure are equal on both sides.

For valves having a circular cross section the pressures will be equal on both sides at the moment of opening (neglect-

ing the weight of the valve), when the valve is proportioned as expressed by the following equation:

$$d_2 = d_1^2 + d_3^2 - d_2^2$$

F. C. HELMS.

Schenectady, N. Y.

Practical Hygrometers

The practical hygrometer described by J. J. O'Brien in the issue of December 29, will, as he says, "be accurate enough for all practical purposes;" but it will tell very little to the observer except that the air is more or less moist at one time than another. To obtain the percentage of humidity in the air by means of the instrument described, a set of tables is needed.

Such tables may be obtained by writing to the United States Department of Agriculture, Weather Bureau, Washington, D. C., inclosing ten cents (the cost of the tables) and asking for "Psychrometric Tables W. B. 235." These tables give considerable very useful information, including the methods of obtaining the formulas, and the use of various kinds of hygrometer. The hygrometer should be hung in a moving current of air.

As an illustration of the need of tables when using the apparatus in question, showing that the difference in temperature between the thermometers is not the only factor to be taken into consideration, if the barometer stands at 30 inches, the temperature of the air is 32 degrees Fahrenheit, and the difference between the wet and dry thermometers is 10 degrees Fahrenheit, then the relative humidity of the air is 2 per cent.

With the air temperature at 80 degrees Fahrenheit and a difference of 10 degrees Fahrenheit between the thermometers, the relative humidity is 61 per cent., a very different figure. The tables also give vapor pressure, and temperature of the dewpoint.

J. G. OULD.

Brooklyn, N. Y.

Indicating Engines

Having two weeks off recently, I decided to try engine indicating. I first called at a lumber mill where there was a Corliss engine rated at 100 horsepower. The superintendent did not think it worth while to bother, but when I told him that I would charge him nothing if the valves were found to be properly set, he agreed. Fig. 1 shows the manner in which the valves were operating.

I next called at a factory where a high-speed automatic engine was in use. The engine seemed to be running nicely, with the exception of a knock in the steam chest whenever the load changed very much. Both the superintendent and engineer were anxious to have the engine indicated; Fig. 2 shows the steam distribution. As will be seen, one end of the cylinder is developing all the power, and the other end is doing negative work. At *CA* is the expansion line and *CBA* are exhaust and compression lines.

The valve did not open to admit steam to this end of the cylinder. The exhaust valve opened at *A*, however, and exhaust steam entered. When the exhaust valve closed at *B* the steam was compressed.

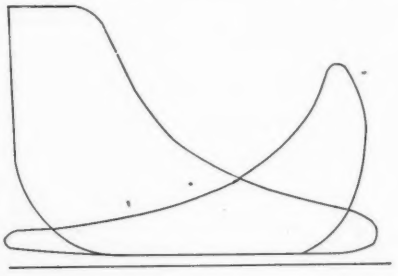


FIG. 1

The expansion line *CA* would lie directly on the exhaust and compression line were it not for the cylinder condensation but, owing to the little steam that does get in being condensed, a partial vacuum is formed in this end of the cylinder, so that the expansion line falls below the atmospheric line.

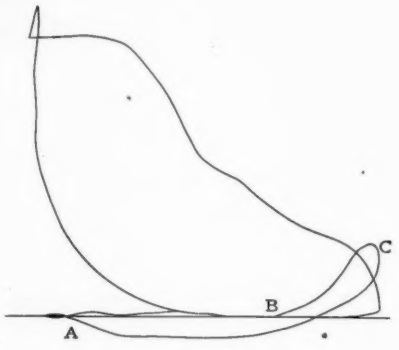


FIG. 2

This engine had been running so long this way that a shoulder was worn on the valve seat, and the valve could not be properly set until the seat was planed off. This explained the knock in the steam chest when the load changed.

I called on another engineer and was treated to a discourse on the slide-valve

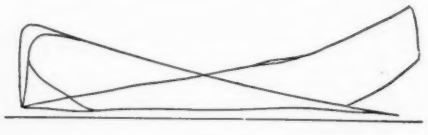


FIG. 3

engine and power-plant operation in general. He wound up by saying that he had been "running engines for 40 years" and had had charge of that particular engine for 12 years.

The president of the company employed me to indicate the engine. Fig. 3 shows what I found. The pencil was held on the drum for three revolutions when the diagram at the left was taken. There was about ¼ inch lost motion in the valve gear; thus, the points of steam distribution were not constant but varied for different strokes. The point of cutoff was varied so that one end of the cylinder would be carrying most of the load during one revolution; then, again, the other would carry the most. This card also shows how the compression and admission varied.

Out of twelve engines I found only one running with proper steam distribution.

RAY L. RAYBURN.

Decatur, Ill.

Central Valve Engines

In a recent issue, J. J. Stafford contributes a description of "central-valve engines," which title, by the way, is a misnomer, as far as the term is understood in England, as the engine fitted with the valve gear which he describes is one of numerous types of high-speed, inclosed, double-acting engine. The term "central-valve engine" applies to a special and altogether different class of single-acting engine, in which type the piston rods are hollow and fitted with steam ports, the valves sliding up and down inside the piston rods, actuated by an eccentric in the center of the crank pin; there being two connecting rods, one on each end of the crank pin, which are worked from a long crosshead; or, in some sizes, from two short gudgeon pins, the whole arrangement forming a very interesting and economical combination.

It is not, however, my main object to point out the misleading definition, but to show that, even if Mr. Stafford is running several sets of high-speed engines, he is evidently not conversant with the most elementary principles of valve setting, as covering the simplest slide-valve engines.

His sketch shows that the two pistons are at the ends of their respective strokes, though how they have got there is a more difficult matter to arrive at, seeing that the lower high-pressure and the upper low-pressure ports are wide open for the admission of steam. He says: "In the position shown the high-pressure piston is at the bottom of the stroke, and the valve has just opened to admit steam to that end of the cylinder." I agree that "the valve has just opened to admit steam," with a vengeance. It cannot open any farther, because the piston valve is almost in its lowest position, and any farther movement of the eccentric will be toward cutting off the steam, before the piston gets far on its way, and the steam in the lower end of the high-pressure cylinder will be on its way to the exhaust, or receiver, before the up-stroke is anywhere near completion.

It is quite sufficient to deal with the high-pressure side alone, in considering the relative positions of the high-pressure

crank and the eccentric (the position of the latter being assumed from the position of the valve as shown). The crank is on the bottom center, and the valve is at the bottom of its travel; therefore, if we imagine a line drawn through the center of the connecting rod and crank pin, that line would be coincident with the center line of the eccentric in its lower position, a peculiar combination, to say the least, and a scarcely workable one.

In the ordinary slide-valve engine, admitting steam to the cylinder from the "outer" edges of the valve, the eccentric is set at 90 degrees, plus the angle of advance, in advance of the crank, but in the class of valve under discussion, which admits high-pressure steam on the *inner* edges of the valve faces, the position of the eccentric is behind that of the high-pressure crank, or, say, 180 degrees from the position required in an ordinary slide-valve engine to run in the same direction. From this it will be seen, on examining Mr. Stafford's sketch, that the top edge of the ring *D*, shown in his Fig. 2, should be just below the top edge of the bottom high-pressure port, thus giving an amount of opening equal *only* to the desired lead for that particular size of engine, instead of giving full port opening in such a position of the piston as shown in the sketch referred to.

In conclusion, I would point out that the relative positions of the low-pressure crank and the eccentric (common to both cranks) are the same as in the ordinary slide-valve engine, and as Mr. Stafford rightly explains, the steam passes through the inside of the valve and over the outer edges of the valve faces, or rings, *A* and *B*, in his sketch.

J. BARNETT.

Manchester, England.

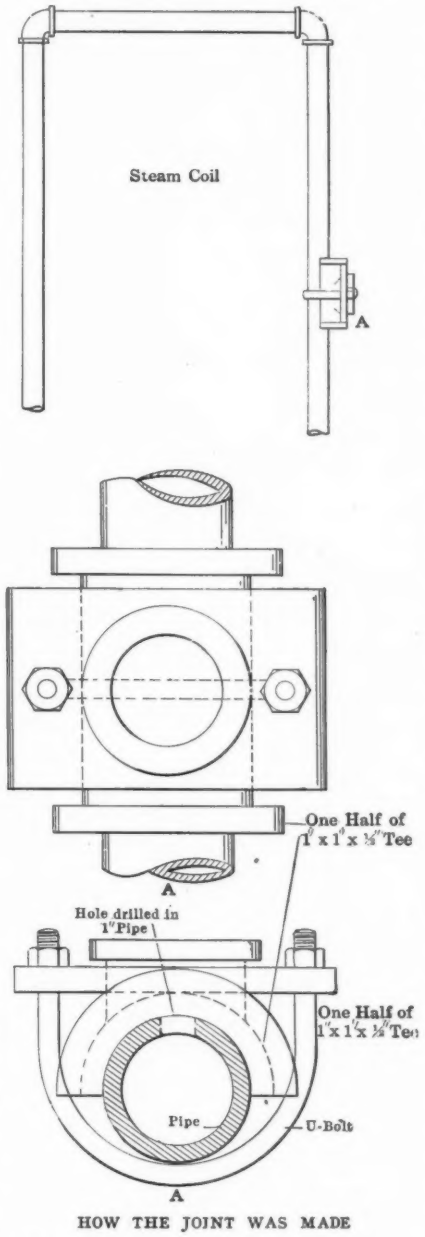
Introducing Steam into Heating Coils

I have charge of a heating and ventilating plant. In the fan discharge there was originally 6400 feet of 1-inch pipe, through which the exhaust steam of a 10x16-inch engine exhausted, the exhaust inlets being along one end of the coils. While handling the maximum quantity of air the end of the coils farthest from the inlet remained quite cool, while the end next to the inlet had a temperature of 120 degrees Fahrenheit.

It happened that on the side of the plenum chamber where the cold air entered, there was one room in particular where the cold air came in underneath and, the building being constructed of concrete, the floor of that room was always cold. There were also in the room a glass skylight, four large windows and four partially glass doors, while about one-third of the partition wall was glass. The occupants of this room complained at various times about it being cooler than the other rooms, which were all heated from the same plenum chamber.

The coils were put together with right-and-left couplings, 9 feet high, and inclosed in a casing of No. 20 sheet steel, with folded seams, riveted together. To take the two coils out, turn them around and introduce exhaust steam from the other side would cost about $75.

The following method was used: The casing was cut about 1 foot high and the



HOW THE JOINT WAS MADE

width of three of the cast-iron bases. A 5/8-inch hole was drilled in three of the pipes and a 1x3/8x1-inch tee bored out so as to make a good fit over a 1-inch pipe, including a 1/16-inch gasket, as shown at *A* in the illustration. The back half of the tee was sawed off behind the branch. A 3/8-inch U-bolt was made to go around the pipe and through a clamp that the branch of the 1x3/8x1-inch tee would take, the gasket was put between the pipe and the tee, the nuts were tightened up on the U-bolt, a good joint was secured, so that steam at any pressure desired could be admitted and an equal temperature in both ends of the plenum chamber obtained.

H. R. ROGERS.

Seattle, Wash.

Commutator Troubles

Referring to the inquiry of A. L. Baker, concerning a commutator trouble, I would state that there are numerous reasons for sparking brushes and commutators. It is sometimes due to poor machine design, and in such cases cannot be remedied by the operator.

Assuming the machine is of good design, the following are some of the common causes of sparking: Badly fitted brushes will increase the surface contact resistance and cause sparking. The contact resistance of a well-fitted ordinary carbon brush is 0.028 ohm per square inch. Poor contact will increase this resistance, which would be of considerable consequence, especially in low-voltage and high-current machines.

Sparking is also due to chattering brushes; sometimes caused by a rough commutator, but more often due to the type of brush holder. For instance, in the case of a holder holding the brush directly in the radial line passing through the center of the brush and commutator, the holder should be changed for one which will hold the brush so as to set about 10 degrees off the radial line passing through the center of contact and commutator, and have the brush trail the commutator.

Another common cause of sparking is high mica, caused by the copper wearing faster than the mica.

I would suggest that Mr. Baker space his brushes at equidistant points, fit them very carefully to the commutator surface and set them so as to be at the neutral point for the load carried.

T. A. LEES.

Quincy, Mass.

I have had trouble similar to Mr. Baker's with a 30-horsepower 220-volt direct-current motor. On this motor the commutator would darken in a short time after the brushes and commutator were sandpapered, which was quite often during the day.

I finally came to the conclusion that the brushes, which were of the carbon type, were too soft and, therefore, tried a harder kind. After the change no further trouble was experienced.

Trouble will also occur where one or two brushes of a set are softer than the others. The soft brushes should be removed and replaced by brushes which are equal to the original brushes in hardness.

If Mr. Baker thinks the brushes on his machine are not causing the trouble, I would advise him to remove the brushes

and give the commutator a good sandpapering in order to remove any roughness, and fit the brushes to the commutator by drawing a piece of sandpaper back and forward under the face of each brush. Start up the machine and wipe a little dynamo oil on the commutator; if possible, run the machine without load for a few hours, wiping a little oil on the commutator occasionally in order to get a gloss.

H. JAHNKE.

Milwaukee, Wis.

I believe the trouble is due either to overload, which causes the machine to heat up, or to a dirty commutator and brushes. Carbon brushes produce a coating on the commutator which insulates and blackens it in spots. This film is liable to mix with the carbon dust, coating the brushes with a nonconducting, sticky substance.

Vibration is another cause of sparking, and a poor foundation will cause the vibration. Belt slipping will also cause sparking, as will weak fields or a ground, and high or low bars will also cause this trouble.

FRANCIS J. DOYLE.

Benson, Minn.

The trouble with Mr. Baker's commutator is that it is not even. I advise him to turn it off and then sandpaper it. The brushes should be adjusted to the load, which will often stop the sparking. A little sandpapering of the commutator while running will, as a rule, keep it in good condition. I also find that a little vaseline used on a commutator keeps it in a smooth, glassy condition.

Why not try a set of graphite brushes in place of the carbon brushes? I find they give good results.

MAURICE W. CAMPBELL.

Brooklyn, N. Y.

I believe Mr. Baker's trouble is due to various causes, such as improper setting of brushes, uneven tension, poor connection between the brush holder and leads, but probably the real trouble is in the commutator.

I have found most of such trouble to be caused by high or flat bars. If the commutator is badly burned on one bar, it indicates an open coil.

H. E. HASLEM.

Paterson, N. J.

A Chronograph

All specifications for steam engines which are to be used as prime movers for electric generators contain a paragraph stating the allowable variation in angular velocity of the revolving parts. This may or may not be lived up to by the builder, and can only be determined by actual test. The following is the description of a chronograph which has been used for this purpose with excellent results.

This instrument consists of a hollow drum made of an alloy of 75 per cent. aluminum and 25 per cent. zinc fastened to a spider and suitably mounted on a bedplate of the same material. The drum is connected to a clock and governor by gears, as is also the feed screw, on which is mounted a tuning fork vibrating 100 times per second. The ratio of the gears and the feed screw is such that the carriage moves about half an inch for each revolution of the drum. Near the end of the tuning fork is mounted a small magnet which keeps the fork in vibration. A general idea of the arrangement of the chronograph may be obtained from Figs. 1 and 2.

When any engine is to be tested six or eight small holes are drilled and tapped at equal distances on the edge of the rim of the flywheel, into which are screwed steel pins about 3 inches long. The chronograph is connected as shown in Fig. 3. A piece of blueprint paper is placed on the drum and the pointer at the end of the fork draws a continuous record, as shown in Fig. 4. A brass nozzle is so placed that a jet of salt water issuing from it will strike each pin in turn, closing the condenser circuit, as shown in Fig. 3, and in discharging through the drum make a spot on the record. After the record has been taken it is a very easy matter to determine the variation in the velocity of the flywheel by comparing the space in time between the spots on the record.

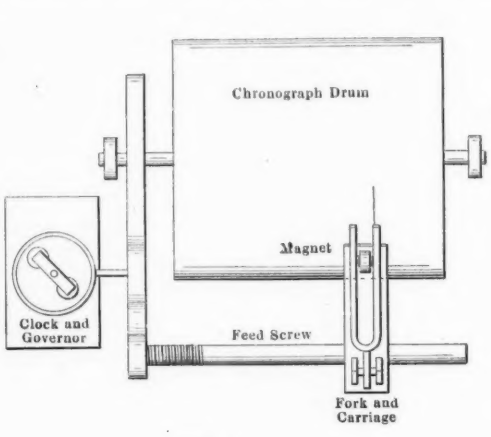


FIG. 1

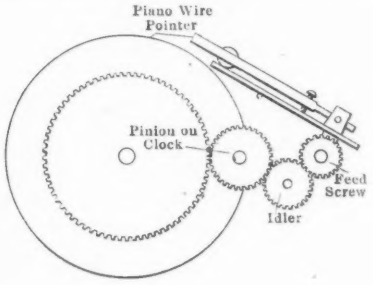


FIG. 2

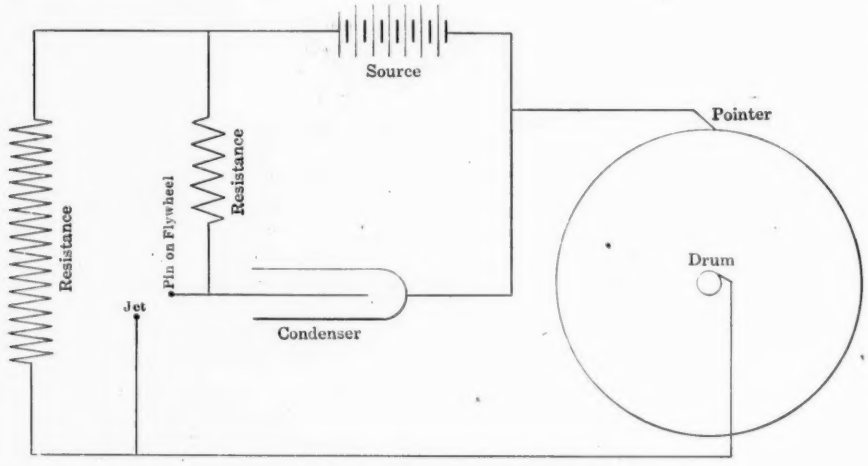


FIG. 3. DETAIL OF CONNECTIONS

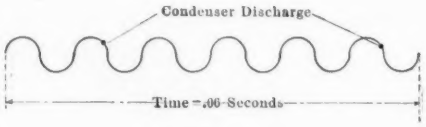


FIG. 4

W. L. DURAND.

Brooklyn, N. Y.

Rope Drive for Governors

In an article in the December 8 issue, by Cornelius T. Myers, is shown a rope drive for governors. It seems to me that its only advantage is the reduced liability of the drive breaking. If the belt shown in Fig. 1 slips, it must be due to looseness of the belt or to "freezing" of the governor.

If the safety stop is adjusted so as to operate before the idler reaches the lower part of the belt, provided the upper part is the slack side, there can be no danger of slipping. If the governor "freezes," then the rope will either slip or break something.

It looks to me as if ball or roller bear-

ings would serve a useful purpose in governor design to eliminate friction.

R. McLAREN.

Berlin, Can.

Mr. Sheehan's Motor Trouble

I have read with a great deal of interest the description by Thomas Sheehan, on page 1011 of the December 15 issue, of a peculiar case of trouble which happened with two compound-wound 250-kilowatt General Electric dynamos, one of which was driven as a generator by a water wheel, while the other was operating as a motor in a mill about half a mile away. The statement that the meters were reversed gives a clue to work from right away. This shows that the polarity of the generator had been reversed by the accident, which could have been accomplished in any one of three ways: By reversing the direction of rotation and the connections of the shunt- and series-field windings, by shifting the brushes back the distance of the pole pitch and keeping the direction of rotation the same, or by reversing the polarity of the field magnet without changing the direction of rotation or the connections of shunt- and series-field windings.

The first two methods resemble each other in that the magnetic flux traverses the magnetic circuit in the same direction in both cases; that is the polarity of the field remains unchanged. It is evident that the polarity of the machine in the present case was not reversed by either of the first two methods, which leaves only the hypothesis that it was reversed by reversing the polarity of the field magnet, which was doubtless accomplished in the following manner:

The connections of the machines are shown diagrammatically in Fig. 1, both the generator and motor-field windings being connected differentially, that is, so that the series-field winding opposed the magnetizing effect of the shunt winding, which has the effect of weakening the field strength as the load current increases.

When the beater was thrown on and pulled the speed of the motor down to a low value this caused a heavy current to flow through both machines, and this current flowing through the series-field windings and aided by the armature reaction due to the large current in the armatures, reduced the field strength of both machines to a very low value. The line current rose to such a value that the series-field winding of the generator completely neutralized the shunt-field winding and reduced the generator voltage almost to nothing, the voltage being merely that due to residual magnetism in the iron.

The rheostats in the shunt-field circuits of the machines were evidently adjusted so that the shunt-field excitation of the generator was considerably stronger than that of the motor, and assuming that the series-field excitation of the two machines was equal for any given current, the ratio of the strength of the shunt winding to that of the series winding was greater in the generator than in the motor. This being true, when the line current had increased sufficiently to neutralize the shunt winding of the generator, the shunt winding of the motor was more than neutralized and the polarity of its field magnet was reversed and built up in the opposite direction by the series winding.

The motor armature was still revolving with considerable inertia and built up a generator electromotive force with the

FIG. 1

polarity at its terminals reversed, but with the current flowing through the circuit in the same direction as before. This is all that was needed to overcome the residual magnetism of the generator and reverse the polarity of its field magnet and, consequently, that of the machine terminals.

As soon as the motor began to act as a generator it slowed down and soon stopped, while the generator, being driven by the water wheel, built up to normal voltage of reversed polarity, which left the motor armature short-circuited across the generator terminals as indicated in Fig. 2.

It is evident that the current in the line and series-field winding of the motor rose to a large value instantaneously, while the current in the shunt field came up very slowly, due to inductance (or not at all, if the field rheostat was equipped with a no-voltage release), hence it is evident that the field of the motor was reversed by the current in the series winding and was also weak, while the

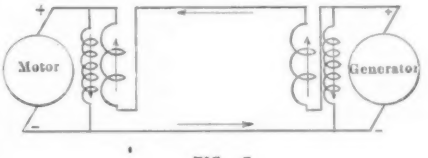


FIG. 2

polarity at the terminals was reversed, which would cause the motor to start backward at a high rate of speed with very poor commutation due to the large armature current and the weak field. Opening the line switch caused the motor to come to a standstill, and if the shunt field was excited, as it should have been, before the armature circuit was closed, the machine would start up in the right direction, but the meters would be reversed, due to the reversed polarity of the generator.

From the foregoing analysis it is evident that the field windings should be changed to a straight compound connection instead of the differential connection, or the same trouble will occur again.

F. C. HELMS.

Schenectady, N. Y.

In regard to Mr. Sheehan's motor trouble, I would say that according to the arrangement of starting, there is no governor on the water wheels, and the gates are throttled for a given load.

When the large beater was thrown on the probabilities are that the gates were not open far enough for the generator to supply the required amount of current to the motor to carry the load, and the motor was brought to a standstill. This practically caused a short-circuit on the generator, still farther reducing its speed and voltage. This low voltage at the generator reduced the shunt-field current and left the fields in an unstable condition. Then, the large armature reactance, caused by the short-circuit current flowing in the armature, reversed the field magnetism of the generator, causing the reversal of polarity which is noted by the action of the meters.

The reason the motor started off in the opposite direction when the beater was thrown off is probably because the motor was differentially wound, and when the motor was almost stopped, and still connected to the line, the current circulating through the series field and armature was greatly in excess of normal, and the magnetic field set up by the series field overcame the weak shunt fields. They were weak on account of the low voltage at the motor, and the required field current was not sent through, thus causing the direction of rotation to be reversed. The excessive speed is due to the weak field.

It is natural that the motor should start up in the right direction after the shutdown, because on starting everything was in normal condition and the shunt field fully excited before the current was applied to the armature. If the line current is reversed, as shown by the meters, it will not change the direction of rotation of any direct-current motor. It would be advisable to have the fields of the motor connected up accumulatively and also recharge the shunt fields of the generator back to their proper polarity.

JAMES E. KILROY.

Lincoln Place, Penn.

With reference to the experience of Thomas Sheehan, described on page 1011 of the December 15 number, I should like to offer the following explanation:

If the field windings were connected up when the machines were shipped by the manufacturer, they were probably arranged for accumulative compounding; that is, the shunt and series fields assisting each other. When such a machine is run as a motor without change of field

connections it will operate as a differential compound motor, the shunt and series fields opposing each other, because the relative direction of current in the series field has been reversed.

When the motor was stalled by the overload, there was, momentarily, an excessive current through the armature and the series field. This produced an excessive magnetomotive force opposing the shunt-field magnetomotive, and must have overpowered it, thereby reversing the residual. The reversed field would cause the motor to reverse its direction of rotation, which condition would endure until the shunt field again established the correct polarity. The weakening of the field on account of the differential action would account for the high speed.

SELBY HAAR.

Schenectady, N. Y.

It is my impression from reading Mr. Sheehan's letter that when used as a motor the machine's series fields were connected as they were originally, when the machine was to be used as a generator, with the result that when the machine was stalled the very heavy rush of current through the series fields was sufficient to overpower the shunt.

The voltage had probably dropped considerably at the same time, so that when the clutch was thrown off, the series field predominated, and the motor then acted as a series motor, reversed and tended to run away. Opening the circuit under heavy load and low voltage reversed the generator so that on starting again the motor operated correctly, the instruments, however, being reversed. It would be interesting to know what did happen at the generator end.

HENRY D. JACKSON.

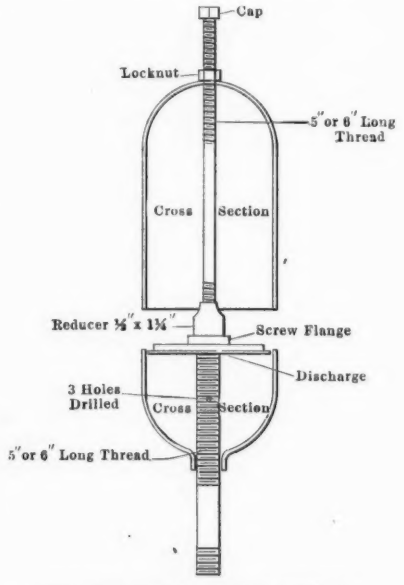
Boston, Mass.

Whistle Made from a Mercury Flask

The accompanying illustration shows a whistle made from a mercury flask. The flask was cut in half, about 3 inches from the filling plug, and tapped at the filling plug for a 1¼-inch pipe. A piece of 1¼-inch pipe, about 10 inches long, was cut with an ordinary thread on one end and on the other end a long thread about 5 inches long, and screwed in the smaller half of the mercury flask.

A disk was cut from a sheet of ⅛-inch copper plate, $\frac{1}{32}$ inch less than the inside diameter of the flask, and a hole cut in the center so as easily to slip over the 1¼-inch pipe. A 1¼-inch screw flange was riveted to the copper disk and screwed on the end of the pipe flush with the small half of the mercury flask. A ½x¼-inch reducer was made a locknut to keep the disk from working loose. The protruding thread was cut off flush with the reducer.

A piece of ½-inch pipe, 13 inches long, was cut with an ordinary thread on one end, and a thread 6 inches long on the other end, and screwed in the reducer. The larger half of the flask was tapped for a ½-inch hole and a ½-inch iron pipe screwed into it. This was screwed onto the 6-inch thread the required distance to



SECTION THROUGH THE WHISTLE

obtain the tone of the whistle and locked with a ½-inch locknut. The other end of the ½-inch pipe was capped.

A. C. HARRISON.

Jersey City, N. J.

An Error in Figures

In reply to the letter written by W. E. Sargent, and published on page 963 of the December 8 issue, I would say in defense of the N. A. S. E. that since Mr. Sargent got his information from the *Boston Globe*, I would much rather believe that the reporter for the *Globe* erred in his report, than to believe that Mr. Sargent was right, as per his formula for a 150-horsepower engine, using 30 pounds of water per horsepower-hour, running 10 hours per day, steam costing $15 per 1000 pounds, or a total of $675,000 per day.

I would suggest the following formula for Mr. Sargent:

$$\frac{150 \times 30}{1000} \times 10 \times 15 = \$675,$$

which would be an unreasonably high cost for power.

I would further add that in a locality where fairly good steam coal sells for $4.50 per ton, figuring about 7 pounds of water per pound of coal, this problem would figure out as follows:

$$\frac{150 \times 30}{1000} \times 10 \times 0.32 = \$14.40$$

per day.

From this result I would rather believe that the Boston association that gave the reporter the estimate on power cost, gave it as from 0.15 to 0.30 per 1000 pounds of steam, rather than from $1.50 to $3, which mistake could easily be made by misplacing the decimal.

C. G. SIGWALD.

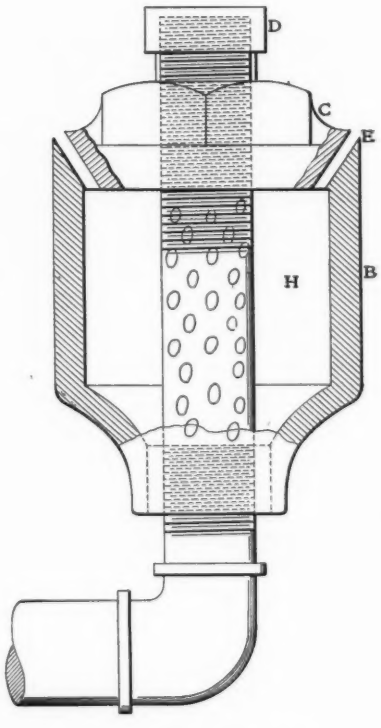
Minneapolis, Minn.

Homemade Blower Head

Herewith is a description of a blower head which I used in the stack of a 60-horsepower return-tubular boiler.

To make it I used a 2x¾-inch reducing coupling, turned out as shown at *B*. A short piece of ¾-inch steam pipe *A*, so threaded as to reach entirely through the coupling 1½ inches at the top, was obtained; also a reducing bushing turned down to cone shape as at *C*, and a ¾-inch pipe cap *D*.

The ¾-inch pipe was drilled with twenty ¼-inch holes, as at *H*, for the steam to pass to the body part of the coupling. The reducing bushing was screwed on, as shown, until the space *E* was $\frac{1}{32}$-inch wide.



HOMEMADE BLOWER HEAD

The idea is that the steam coming out in funnel shape will catch the entire column of air inside the stack and force it out, where a simple piece of pipe would only set a core of air in motion in the center of the stack.

HERMAN E. KING.

Columbia, S. C.

A Concrete Feed-Water Storage Tank

Why Such a Tank Is the Most Serviceable; Plain Directions for Building One; Used for Water Softening, Also, with the Lime Process

BY WARREN H. MILLER

Whenever a power plant uses city water, or, in fact, any source of feed water other than the direct suction of its own feed pumps from some natural supply on the ground, this feed-water supply at once becomes the most vulnerable point in the power system. Stoppage of this supply ties up everything. It is always sudden; it seldom lasts long; but in the short hour or so that it does last, there is nothing for it but to bank fires and shut off the steam all over the plant. Those who have managed large steam-distribution systems do not need to be reminded of what a dangerous, uncertain business starting all this up again is.

If it is the city water you are dependent upon, your first notice is usually of the man with the monkey wrench, who announces that your main is going to be shut off in half an hour to make some change five blocks up the street. Or else it is a telephone call, to the effect that a main has burst and *your* main will be out of business until the street is dug up and the thing repaired.

If you pump your own feed water from a well, your shrift is likely to be still shorter. The well-pump steam valve sticks, and you have precisely the capacity of the small storage tank to run your boilers on. In fact, it is absolutely essential to provide three or four hours' storage capacity for boiler-feed water. You must do this cheaply, and not use up any valuable building space, nor get too far from the power plant.

A cylindrical iron tank possesses a number of disadvantages. It holds little water for the land it occupies; it is expensive to buy and have delivered on the ground, besides requiring to be assembled on the foundation; it carries a depreciation of about 10 per cent. per annum and you can count on cutting it up for junk in fifteen years; it requires massive underpinning, unless the corner of some brick firewall is handy to the power plant, and heavy foundations if set on the ground. The cypress-stave tank is better, but has the same objections as to depreciation of iron work, area of floor space, etc.

Rectangular Concrete Tanks Best

On the whole, the rectangular reinforced-concrete tank offers the best proposition. It is easy to find ground space for it, in some angle around the power-house chimney, for example. It has no depreciation and requires no repairs. It costs hardly more than the foundations for an iron or wood tank. And, at about the time you are thinking of replacing the latter because of old age, the concrete tank will still be gradually approaching its maximum strength—which is after the fashion of an asymptotic curve, as the mathematicians would put it.

The most economical way to get the thing up is to put most of the tank under ground, and leave not more than 6 or 8 feet above ground to resist water stresses. These mount up surprisingly with the hight. At 6 feet, the point of maximum pressure will be 432 pounds per square foot at ground level. It is entirely permissible to neglect the water pressure below ground. Even in poor soil, the resisting capacity of the earth surrounding the tank walls below ground can be taken at two tons per square foot, precisely as in foundations.

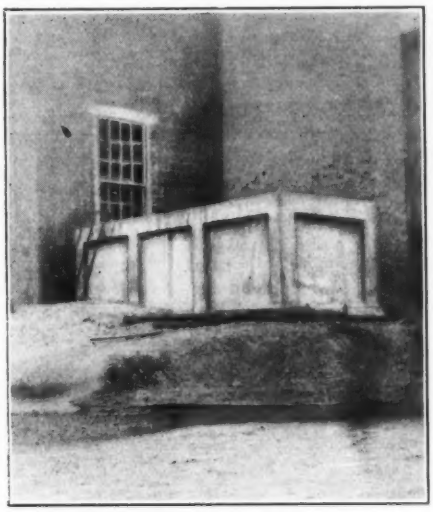


FIG. 1

A pit is first dug, with plumb sides equal to the outside dimensions of the tank, and a footing or floor of concrete, some 9 inches thick, laid down. Next, a box form of the inside dimensions of the tank is set up, and the space between it and the pit walls filled with concrete up to 2 feet below ground level. The reinforcing rods for the above-ground section can now be set in place, and the work poured to ground level, securing the rods in position.

The design shown for the portion above ground, Fig. 1, makes a pleasing, strong, and economical construction. The pilasters are figured as beams to carry the whole load of the panels, and reinforced accordingly. The panels are treated as floor slabs, figured on the pressure of water per square foot at ground level.

Constructing the Tank

The first carpenter work will be to set up the outside forms, Fig. 2, and nail the expanded metal to them, N-shaped separators of 1x⅛-inch flat strip steel being used to hold them off the surface of the forms. Another scheme is to drive two nails crossing at the intersection of the diamond meshes of the expanded metal. A single nail driven at the proper slant will also serve to hold the reinforcement about an inch off the forms, but is weak and liable to come out in the ramming and placing of the concrete. It is mentioned here because carpenters are too apt to discover this method themselves, and to work it with enthusiasm as being the easiest possible method.

A dense, impervious *cinder* concrete should be used. The 1:2:4 mixture gave very good results in the tank illustrated. It will have no bad spots in it, nor will it leak or sweat. Rock concrete is not permissible. Remember that you are pouring into a thin crack, only 5 inches wide including the expanded metal. The actual space in which to pour is only 4 inches. Rock is sure to bunch and jam. If you ram it, it crowds the expanded metal out against the form. Of course, before pouring, the interior forms must be struck in the lower section and raised to match the outside forms, and the sheets of expanded metal which reinforce the roof must be placed, lapping down a foot or so into the wall forms; also the longitudinal reinforcing rods of the cornice, which is figured as a panel beam like the pilasters.

The ceiling is poured with the same cinder mixture. Four inches is plenty deep enough, using only expanded metal to reinforce the slab. The walls and bottom of the tank should be plastered all over ⅜ of an inch deep with 1:3 cement mortar. Do not allow any lime in it, as lime-cement mortar soon becomes pervious under water pressure.

In the tank shown in the illustrations, the reinforcing was used and figured clear around the tank. This was because all but the bottom was laid in soft, unpacked,

anthracite-cinder filling. The city water was led into it at ground level from a spur of the suction piping. When using the tank water, the meter valve was closed and the tank valve opened, when the feed-pump would suck it back through the same pipe.

It often occurs that there is exhaust steam, not otherwise condensable, which may be led into the feed-water tank. If a tee is left on the main exhaust pipe, and is well worth while, being inexpensive and in no sense a nuisance.

Tank Suitable for Water Softening, Also

A farther use for this tank is for water softening where the lime process is used. There is plenty of depth for settlement, and the large 24x24-inch manhole in the ceiling gives facility for handling the sludge. If boiler compounds are used, was charged with its quota of compound. To do this, the drip in the bottom of the charger was opened, and the feed water drained out of it. It was then filled by way of the funnel at the top with a saturated solution of the compound. The connecting nipple valves were then opened and the main feed gate shut, thus forcing the incoming feed water to pass through the charger driving along the compound before it. As only one set of boiler checks was left open, that particular boiler received the total charge intended for it.

The actual cost of the feed-water storage tank described was $482.26; the iron tank which it replaced cost $648.68, including $120.56 for a foundation of 10-inch I-beams cut into brick walls across a 14-foot alley between two buildings. This is the cheapest possible foundation. Supposing that the iron tank were to be placed on concrete piers on the site of the present tank, the tank being 12x12 feet, five piers would be required besides the footing. With the top of the piers 2 feet above grade and the bottom of the footings 4 feet below, the estimated cost of this foundation would be about $140. As the tank itself cost $528.12, set up, to replace the concrete storage tank with a steel one on the same site would cost $668.12. The cubic contents were identical.

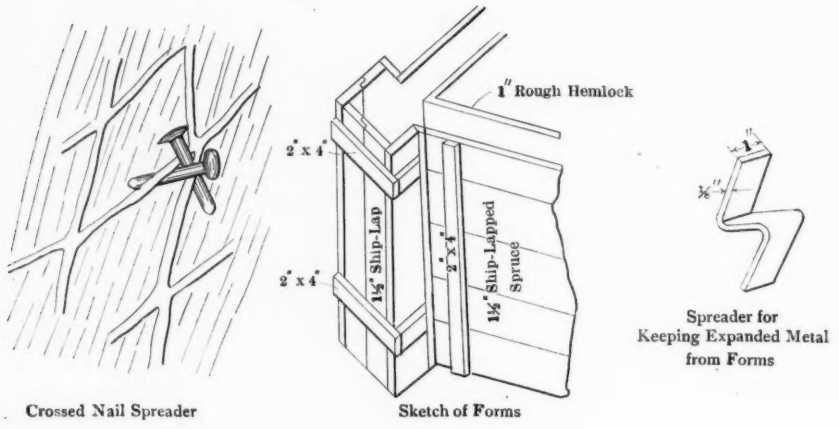


FIG. 2

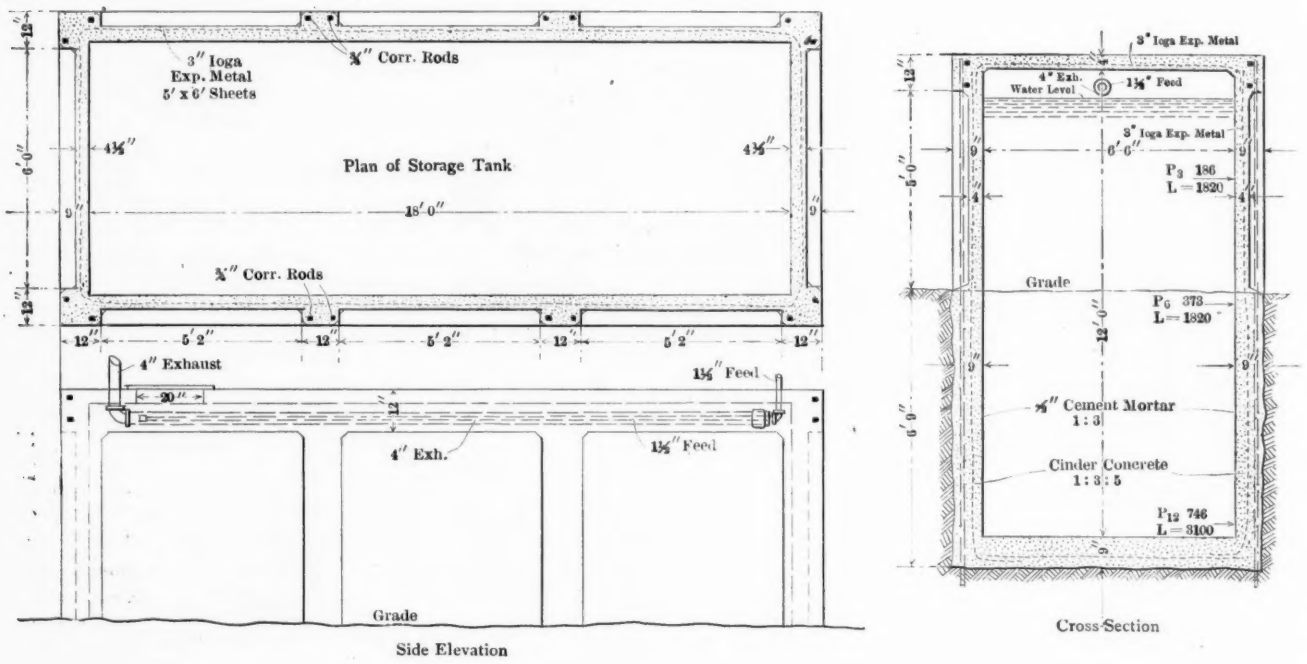


FIG. 3

a suitable pipe led off to the tanks, much of this steam will be condensed and give a preliminary heating to the feed water. This pipe should run the length of the tank just above the water. Into the opposite end enters the water-supply pipe, about 1½ inches in size, and perforated all along the top with ⅜-inch holes. A large surface of cold, flowing water is thus exposed to the incoming steam, and a quantity of heat interchanged. This economy the writer prefers to introduce the charge directly into the feed line. For that purpose, a 4-inch nipple, capped at both ends, exactly held a charge for one boiler. This was by-passed around the main feed-line gate valve by attaching it above and below with ¾-inch nipples with a ¾-inch union and valve in each nipple. A drip valve was put into the bottom cap, and a feed valve and funnel tapped into the top. Just after blowing down, each boiler in turn

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When the terminal pressure of an engine cylinder is practically equal to the back pressure, as in some compound engines, the mean effective pressure formula reduces to

$$p_m = 1 + p_b \log R,$$

p_b being the back pressure.

Electric Dynamometers

By G. Everett Quick

Motors have often been rated from so-called power determinations in which the power was absorbed by crude devices or standard machines giving merely an estimated value, subject to wide variations. A true test worthy of the name, requires some means of loading by which observations may be made for accurately computing the power developed. The apparatus for doing this is called an "absorption dynamometer," while a transmission dynamometer is an apparatus by means of which the mechanical power delivered by one machine to another may be measured.

The simplest type of absorption dynamometer is the friction brake, which is made in various forms. In all forms of this brake, the force opposing rotation is obtained by the friction of a revolving pulley with a strap, disk, or wooden arm adjustably clamped to it. If these are clamped to the pulley and allowed to revolve freely with it, the load is zero, but if held stationary, the weight or spring required to hold the brake from revolving is a direct measure of the power absorbed by the friction. Fig. 1 shows an outline sketch of a prony brake, in which A is the friction wheel, L the horizontal distance of the weight from the center of the wheel, which is the radius of the circle which would be described by the suspended weight if it were allowed to revolve with the friction pulley. The imaginary speed, in feet per minute, which this weight would attain under these conditions, multiplied by the weight opposing this rotation, gives the power absorbed in foot-pounds per minute. The imaginary speed is obtained by multiplying the length L of the arm by 6.2832 and multiplying this product by the revolutions per minute made by the wheel A. In short,

$$6.2832 \times \textit{Rev. per min.} \times \textit{Arm length} \times \textit{Weight} = \textit{Foot-pounds per minute},$$

and

$$\frac{\textit{Foot-pounds per min.}}{33{,}000} = \textit{Horsepower}.$$

By the use of a chart similar to that shown in Fig. 2, separate calculations for each reading may be avoided. A chart for each length of brake arm is required.

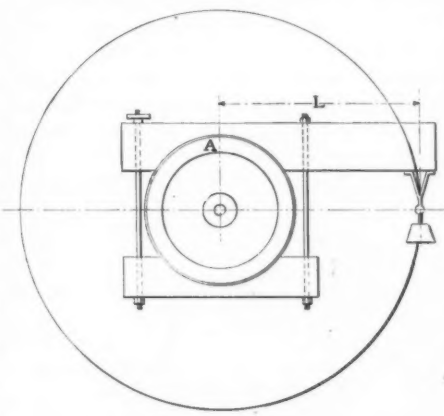


FIG. 1. SIMPLE PRONY BRAKE

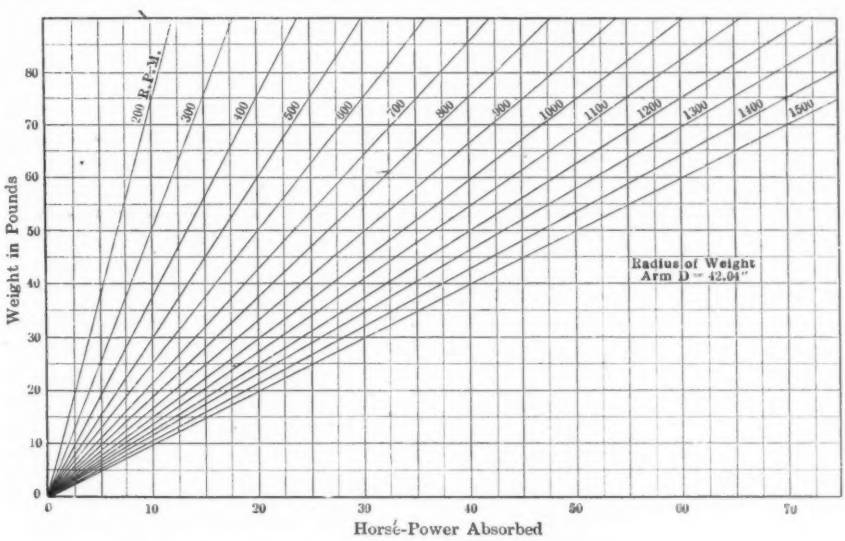


FIG. 2. REFERENCE CURVES FOR DYNAMOMETER

Electric Dynamometers

The well known prony brake is still used in the great majority of tests, and on account of its simplicity and low initial cost, and in spite of its inherent defects, it will no doubt always be widely used. However, other types, such as the Alden brake and the electric dynamometer have been developed which are practically free from the erratic and excessive vibrations characteristic of the prony brake, and mechanical power absorbed by these types may be accurately measured within a fraction of 1 per cent. Furthermore, the two classes of apparatus mentioned are not only used for loading small units, but may be made in single units capable of absorbing far more power than can be satisfactorily absorbed by a single prony brake.

In all types of electric dynamometer, an electric generator, usually a direct-current machine, transforms most of the mechanical energy of the test motor into electrical energy, which in turn is dissipated as heat in an external circuit, or in the armature itself. Under certain conditions, the power ordinarily wasted in rheostats may supply useful power to other circuits.

The best known type of electric dynamometer, and in fact the only one which has been extensively used, is the standard electric interchangeable motor or generator connected by belt or flexible coupling to the test motor. When used to load motors of widely varying speed, the belt drive with different pulley ratios is necessary. Since the power absorbed is measured by the generator output in electrical units, the variable losses of the driving belt and armature resistance make a calibration curve very uncertain. With direct drive the curve is more reliable, although subject to variations due to the variable resistance of the generator conductors. The electric output and consequently the load on the motor, is controlled by passing the electric current through an adjustable rheostat. For small capacities a metallic rheostat, usually of the iron "grid" type, may be used, but for medium and large capacities the well known water rheostat is more practicable.

The so-called "cradle" dynamometer differs essentially from the above only by suspending and balancing the field frame of the generator on knife-edges or frictionless bearings and measuring the power by the torque between the field magnet and the revolving armature. It affords an easy, accurate and efficient means of obtaining instantaneous readings of the brake horsepower of an engine and also of putting full load on it for a continuous running test without excessive heating of the dynamometer. It may be used as a transmission dynamometer to give instantaneous indication of the power required to operate any particular machine by noting the pounds pull exerted at the end of the weight lever and the speed of the rotating armature. It affords a simple and accurate method for determining the horsepower required to operate test machines without the necessity of calculating efficiencies, reading electrical instruments, etc., as would be required with the usual method of testing with a standard electric motor. Owing to the simplicity of apparatus and calculations, the test may be made by comparatively inexperienced attendants.

The general arrangement of the electric dynamometer as manufactured by the Sprague Electric Company, is shown in Fig. 3. The machine consists of a specially constructed direct-current generator, of the familiar circular-yoke type, with compensating poles. The machine is supported on ball bearings in such a

manner as to permit the field magnet to oscillate about the armature, remaining concentric, of course, in order that it may revolve freely under all conditions. Two arms extend horizontally from opposite sides of the field-magnet frame to which they are rigidly secured. The short arm or balance lever contains an adjustable weight to balance the complete dynamometer on its bearings. The long arm or weight lever is provided at its outer end with a hanger similar to that on an ordinary platform scale, on which slotted weights may be placed, or if preferred a spring scale may be used for measuring the pull exerted at the end of the lever when the dynamometer is in operation.

The torque exerted by the revolving armature on the field magnet tends to carry the frame around with the armature, and this torque acts in a similar manner to that of the frictional resistance of the friction brake, but without the objectionable vibrations.

Although the electric dynamometer is used more for absorbing a known mechanical power, it can also be employed as a combined motor and indicator, driving a machine and at the same time measuring the power required to do it, thereby serving as a simple transmission dynamometer.

The current for driving is obtained from any direct-current circuit of suitable voltage. The commutating poles afford a very wide range of speed control by varying the field strength with the rheostat connected in the shunt-field circuit of the machine.

Owing to the fact that this dynamometer can be used regularly as a power motor for driving shop equipment, comparatively little added capital is required to avail oneself of such a test outfit.

Eddy Current Dynamometer

A special form of electric dynamometer is the so-called eddy-current brake, which meets with a somewhat limited use as an absorption dynamometer for comparatively small powers when a continuous load is required. The field-magnet yoke and attachments are constructed and balanced essentially the same as in the previous type, although the field excitation must be obtained from a separate source. The armature, instead of having the customary winding and commutator with connections to an external circuit, is made up of copper disks or other short-circuited conductors in which currents are set up by rotation with the field and the heat thereby generated is dissipated to the atmosphere by radiation and connection without recourse to an external rheostat. However, a small rheostat is required in the field circuit for regulating the strength of the field magnet, and consequently the load absorbed.

The rotor of this dynamometer is very rigid and is not subject to electrical breakdown; there being no armature wiring, commutator or external circuit, the initial cost is less than that of the dynamo type. Obviously, the capacity of this type is limited to small powers as only a limited amount of energy can be dissipated in the form of heat by air cooling. However, the temperature of the rotor may be allowed to reach a much higher value than that allowed in the dynamo, since no combustible material need be used in its construction.

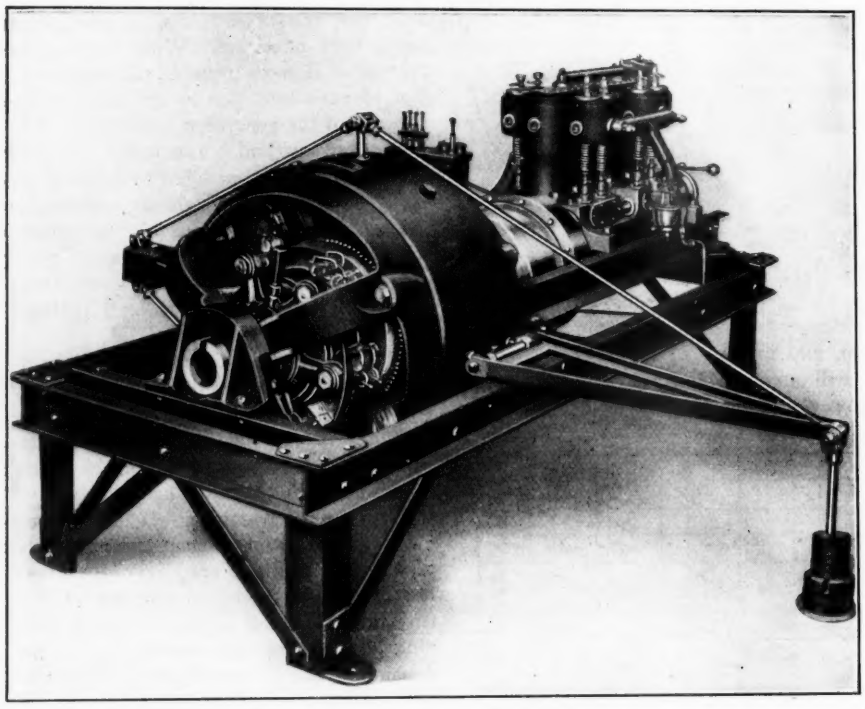


FIG. 3. ELECTRIC DYNAMOMETER COUPLED TO AN AUTOMOBILE ENGINE

Compound Cylinder Ratios for Equal Work

In the following is shown, step by step, the derivation of the formula by which was prepared the table of cylinder ratios, on page 215 of this number:

Let I = Initial pressure absolute,
t = Terminal pressure absolute,
b = Back pressure absolute,
R = Ratio total expansion,
r = Volumetric ratio of cylinders,
$M.P.$ = Mean pressure,
$M.E.P.$ = Mean effective pressure.

$$R : 1 + \log_{\varepsilon} R :: I : M.P.$$

$$M.P. = \frac{I\,(1 + \log_{\varepsilon} R)}{R} = \frac{I}{(1 + \log_{\varepsilon} R).} \quad (1)$$

But $\frac{I}{R} = t$ and

$$M.P. = t\,(1 + \log_{\varepsilon} R). \quad (2)$$

$$M.E.P. = M.P. - b.$$

So that

$$M.E.P. = t\,(1 + \log_{\varepsilon} R) - b. \quad (3)$$

If the work is to be equally divided the mean effective pressure in the low-pressure cylinder will be

$$M.E.P._1 = \frac{t\,(1 + \log_{\varepsilon} R) - b}{2} \quad (4)$$

and the *mean* pressure in that cylinder

$$M.P._1 = \frac{t\,(H \log_{\varepsilon} R) - b}{2} + b. \quad (5)$$

By transposing formula (2) it is seen that

$$\log_{\varepsilon} R = \frac{M.P.}{t} - 1. \quad (6)$$

Substituting for $M.P.$ the value given by formula (5) the $\log_{\varepsilon}$ of the ratio of expansion in the low-pressure cylinder (which is the same as the volumetric ratios of the cylinders, for the contents of the high- are expanded to the volume of the low-) is found to be

$$\log_{\varepsilon} r = \frac{\frac{t\,(1 + \log_{\varepsilon} R) - b}{2} + b}{t} - 1 =$$

$$\log_{\varepsilon} r = \frac{\log_{\varepsilon} R + \frac{b}{t} - 1}{2} \quad (7)$$

when $\frac{b}{t} = 1$, i.e., when the diagram ends in a point this reduces to

$$\log_{\varepsilon} r = \frac{\log_{\varepsilon} R}{2}, \quad (8)$$

and since halving a logarithm gives the logarithm of the square root, formula (8) simply means that for the condition cited

$$r = \sqrt{R}.$$

Heat in Steam

By Joseph H. Hart

The question of the amount of heat in steam under various operating conditions, the quantity of this heat available for transformation into work and the various relations of this heat quantity which produce condensation and superheating and other equally important changes in the steam content is a question of the greatest importance not only to the designing engineer, but to the operating and stationary engineer as well. As a general thing almost every man familiar at all with the operation of steam engines has a little information in regard to the subject of heat units and a number of heat changes and the amount of heat available under certain circumstances, but in regard to all the heat relations possible in steam under various conditions of operation they are not familiar. Thus such statements as the one that the quantity of heat in steam is approximately the same independent of its temperature is one not easily understood. Again, the statement that the specific heat of saturated steam is negative leads to an interesting situation and one not clearly understood by the average operator. These two examples will serve to illustrate the type of difficulties which arise, and it is the object of this article more fully to explain the connection of heat and steam, the variation of amount with temperature and the variability of the quantity available for transformation into work under various standard conditions and the causes of steam condensation under conditions not clearly understood.

Thus it is assumed that the average engineer or reader of this article is more or less familiar with the definitions of specific heat and latent heat and has a clear conception of what is known as heat quantity. Specific heat is defined as the quantity of heat required to heat one pound of material one degree Fahrenheit, measured in B.t.u., where a B.t.u. is the quantity of heat required to raise one pound of water one degree Fahrenheit. Thus heat quantity is referred to heat held by water under varying conditions, and the specific heat is often defined as the ratio of the heat under certain circumstances to that in an equivalent mass of water under the same circumstances. Latent heat is defined as the quantity of heat required to change the state of a body without change in temperature, and it is generally known that this latent heat is given out in condensation or solidification, but absorbed in liquefaction or vaporization. However, this definition is not general enough and often leads to considerable ambiguity, whereas a broader statement of the case would explain many difficult facts as they arise and will not complicate the conditions at the outset in any respect.

Latent Heat Potential Energy

A rise in temperature of a body is nothing more or less than an increase in the kinetic energy of the molecules. The temperature of a body measured by the absolute scale is directly proportional to the mean kinetic energy of the molecules, and these can best be regarded as little bullets flying around through space, in the case of a gas, and producing pressure by their multitudinous bombardment. In a liquid they are fastened together by some unknown bonds, probably similar to gravitation, but still free enough to possess a certain free path and hence capable of possessing kinetic energy. Thus, when a pound of water is heated one degree, a portion of the heat, or energy, is used to raise the kinetic energy of the molecules and a portion used to cause expansion or a stretching of the bonds which tie the molecules together. Latent heat is in reality potential energy of the molecules, or energy of position, and the molecules of water changed into steam possess potential energy of position in exactly the manner that a ball thrown above the surface of the earth, until it escapes the influence of gravitation, possesses energy of position. The molecules of steam have possessed at one time sufficient kinetic energy to rise from the surface of the water due to their motion, against the force of cohesion, hence losing a portion of their velocity exactly as a ball thrown into the air does in rising higher and higher.

When water is heated one degree, a certain amount of heat or energy is used in raising the temperature or kinetic energy of the molecules of the water, and a small fractional part is used up in producing the change of relative position and is apparent as potential energy. The molecules have a variable speed ranging over several thousand per cent., and the average or mean velocity or energy only is considered. When the water gets to the boiling point, some of the molecules possess sufficient speed to rise high enough above the mass of liquid to become practically free from their attractive power and they lose during this maneuver a large amount of their kinetic energy, possessing, after separation, approximately the same average kinetic energy as the average molecule in the liquid. The removal of the high-speed molecules means a diminution in the average speed of the remainder, and hence a fall in temperature unless heat is supplied. This supply, in reality, is the latent heat of steam. After the water is changed to steam, the steam then possesses practically nothing but specific heat, or rather increase in temperature means an addition only in the kinetic energy of the molecule. This is actually the case in what is known as superheated steam, in which case the steam behaves as a perfect gas and obeys Boyle's law and Charles' law absolutely.

What Happens if the Pressure Above the Steam is Increased

If the pressure above the steam is increased, this fact means that the molecules are crowded together and a great many more collisions occur among the molecules endeavoring to escape from the surface of the water, and that a larger kinetic energy per molecule must exist for evaporation to go on, or simply that the temperature must rise before evaporation occurs. This is the reason for the rise in temperature of the boiling point with increase in steam pressure. The molecules, however, lose a similar percentage of their kinetic energy in escaping from the water and attaining their position, with its corresponding potential energy, as steam, and hence the latent heat or quantity of heat used up in potential energy is diminished, and hence the further phenomenon of a fall in latent heat of vaporization with rise in temperature of the boiling point. The fall in latent heat or potential energy required compensates largely for the increase in apparent heat or kinetic energy, so that the total heat in the steam is the same as the potential energy of position of the molecules plus their kinetic energy or energy of motion. This latter undoubtedly varies with rise in temperature, but the specific heat of steam at this temperature, or the quantity of energy required to raise the kinetic energy of the molecules the fractional amount required per degree, is so small a percentage of the total energy involved that it is often neglected.

It is possible under these circumstances, at least theoretically, to increase the pressure on steam to a sufficient extent to eliminate the latent heat of position entirely. If the molecules are sufficiently packed to prevent separation from the liquid, the energy of position practically disappears and the molecules increase their kinetic energy only, and this phenomenon occurs at what is known as the critical temperature, pressure and volume respectively.

Action of Steam in Contact with Water

Steam in contact with water possesses anomalous behavior under varying conditions. The number of molecules in a given volume of steam at a given pressure, if the steam is saturated, that is, at the temperature of the water in contact with it, is a certain definite quantity which varies under certain conditions. The best explanation of the phenomenon here is that there are so many molecules in the steam that as fast as fresh ones arise from the water and produce steam, others from the steam enter the water and are condensed or lose their energy of position and acquire an increased energy of motion due to the attractive force exerted upon them. The molecules in the steam and water possess the same average kinetic energy, hence the same

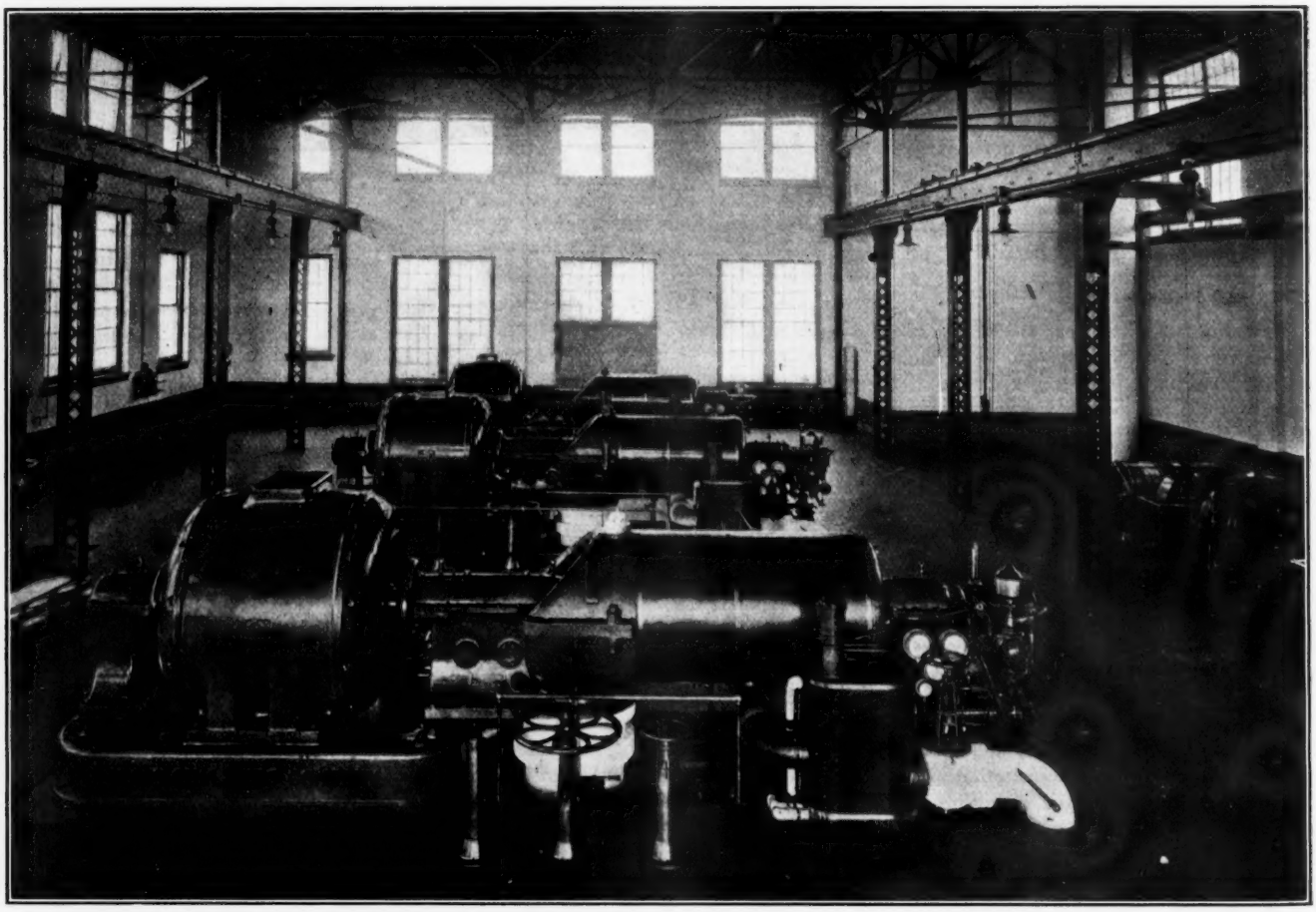
temperature, and only a certain number can exist in the steam, and the transfer of molecules to the steam from the water with the consequent loss in kinetic energy and production of potential energy of position, is exactly counterbalanced by the number of molecules of steam transferred from the steam to the water with their consequent loss of potential energy of position and equivalent rise in kinetic energy. Any increase in pressure on the steam or diminution in the volume of the same results in a crowding of the molecules from the steam into the water, with a corresponding increase in the average kinetic energy or temperature of the water and of the steam as well, since there are then less molecules in the steam and less potential energy in the system, with an increase in the average kinetic energy of all the molecules. This condition explains in reality what is known as the negative specific heat of saturated steam.

When steam in contact with water is heated one degree, the kinetic energy of the entire mass of molecules in both the water and steam is increased a certain definite percentage depending upon the absolute temperature of the system. The increase in kinetic energy of the molecules in the steam results in an increased pressure which means that a number of the molecules are transferred automatically to the water and give up their latent heat of position, which energy is apparent in increased average kinetic energy of the molecules. This energy results in a further rise in temperature. Hence when heat is added to a mixture of water and steam, or what is known as saturated steam, the amount of steam actually diminishes in quantity as determined by weight. The temperature of the water is raised a much larger amount than the heat put in would warrant according to the specific heat of the water, and the extra heat that is evolved in increased rise in temperature of the water and steam comes from the latent heat of condensation of the fractional part of the steam which disappears. Hence arises the statement of the negative specific heat or the production of heat with rise in temperature of saturated steam.

Cause of Much Difficulty in Design and Operation

This anomalous behavior of steam in contact with water is the cause of much difficulty in steam design and operation. Saturated steam, that is, steam in connection with the water in the boiler, changes in amount with every variation in pressure and volume of the same and does not behave as a normal perfect gas would under the circumstances. Thus with saturated steam entering the cylinder of a steam engine, the increase in volume which results from expansion in the cylinder and the transfer of a portion of the kinetic energy of the molecules into energy of the piston, results in a diminution in the kinetic energy of the molecules sufficient to cause a portion of the steam to change into water and to give up its latent heat, in order to maintain the temperature normal for saturated steam at this pressure and temperature. Hence, the phenomenon of cylinder condensation which is augmented greatly by the further radiation of heat through the walls.

Sufficient has been shown to warrant the statement that the behavior of steam under all conditions of operation and theory is a purely mechanical one, and the transfers of kinetic to potential energy and *vice versa* are responsible for all the anomalous conditions existing in the utilization of steam. Any difficulty or misconception or ambiguity that arises in the utilization of steam can be explained and clearly understood by a reference to the kinetic and potential energy of the molecules. This latter conception, known as the kinetic theory of gases, is the basis of thermodynamics and has suggested many possible developments of a mechanical nature which are used in practical applications to eliminate the more serious difficulties in power production in this field.



THREE ALLIS-CHALMERS STEAM TURBINES AND GENERATORS, EACH 750-KILOWATT 3-PHASE 60-CYCLE 2300-VOLT, INSTALLED IN THE NEW POWER PLANT OF THE PACIFIC MILLS, LAWRENCE, MASS.

Heat Losses in an Electric Power Station

At a recent meeting of the Institution of Civil Engineers, a paper was read on "An Investigation of the Heat Losses in an Electric Power Station," by F. H. Corson, of which the following is an abstract:

An inquiry, originating from Blackburn, in 1903, showed that the average coal consumption of 34 principal generating stations of the United Kingdom was about 7.7 pounds per unit generated. The figures ranged from 3.6 pounds to 15 pounds, Blackburn standing at 10 pounds. Rough tests on the various sections of the plant resulted in considerable rearrangement. The steam-pipe system was overhauled and more effectively drained, and steam separators and driers were in consequence dispensed with. Engine stop valves were, where possible, attached directly to the main steam pipes. The steam ring was discarded, and generally the effective heat-radiating surface was greatly diminished. Better-fitting boiler dampers were provided, the condition of the brickwork was improved, and the whole process of combustion was more thoroughly controlled by the institution of flue-gas analysis. These and similar alterations occupied about three years, and the fuel consumption fell during that time to about six pounds of the same coal per average unit generated, a reduction of 40 per cent. Further progress being imperative, it was decided to conduct tests covering the whole operation of the works, viewing the losses peculiar to each part of the plant in their relationship to each other and to the whole; and arrangements were made, and apparatus devised, for their prosecution. After isolated trials of the various types of apparatus had proved their reliability, simultaneous tests were arranged, of a duration long enough to embrace all conditions of operation met with in routine work.

The Blackburn undertaking comprises two adjoining stations of 2300 kilowatts capacity each, containing 12 mechanically fired Lancashire boilers, six fitted with superheaters; 15 high-speed engines driving generators from 60 to 775 kilowatts in size, controlled from three switchboards; steam piping 3 to 14 inches in diameter; ejector and jet condensers fed from an overhead water tank above the boiler house; low-speed steam-driven feed pumps; four batteries of economizers totaling 1504 tubes; two chimneys, 150 and 250 feet high, respectively. The test has covered during 168 consecutive hours the combustion of about 230 tons of coal, the evaporation of 3.376 million pounds of water, and the generation of 99,295 electrical units. The net results show a consumption of 5.15 pounds of coal, and a total evaporation of 33.9 pounds of water per average unit.—*Mechanical Engineer.*

Purchasing and Burning of Coal

By H. W. Richardson

The purchasing of coal for power plants of any great size should receive a great deal of consideration, as the economy of the plant depends much on the quality of the fuel which is burned. In not a few large concerns all coal is purchased by the company's purchasing agent, who in most cases does not understand the peculiar charcateristics of coal and seldom, if ever, does he consult his engineer before making a purchase.

All coal companies sell the very best fuel obtainable, according to their agents, and the man who can show the purchasing agent a coal which is of high B.t.u. value and at a low price will invariably obtain the contract. The coal is then sent to the power plant and the engineer's troubles begin. The purchaser of the fuel understands that the coal contains a great many heat units, but he is generally ignorant of the conditions under which the coal is to be burned. What I wish to make plain is that the B.t.u. value does not show that the coal is just what is wanted for any particular plant. Every plant is, of course, equipped with certain grates or stokers, and these furnaces may be adapted to some fuels, but will not burn other grades economically.

The B.t.u. value of coal is determined principally by the amount of ash. One coal may show by analysis 15 per cent. volatile, 75 per cent. fixed carbon and 10 per cent. ash; another coal will show 25 per cent. volatile, 65 per cent. fixed carbon and 10 per cent. ash. The B.t.u. value of these two coals will be the same, but they do not burn equally under the same conditions. For a poor furnace the high volatile coal is unsuitable, and in many installations no adjustments are possible that will better the results. In this case, if a low volatile coal is tried, it will often solve the difficulty.

The coal dealer explains to the purchasing agent that his coal is high in heat value and offers it at a good figure, which will invariably attract the purchasing agent and cause him to purchase a large amount. He does not understand furnace peculiarities, and it is then up to the engineer to burn the coal, and if results are not forthcoming he is sure to meet with severe criticism. In a particular case where conditions were as stated above, the excess amount of cheap fuel burned made it in reality more expensive, simply because the fuel was not adapted to the plant. The adaptability of the coal is more necessary in stoker plants than in hand-fired plants. In practically all stoker furnaces it is absolutely impossible to use any fire iron. Some coals, even among those of high heat values, will not burn properly unless they can be worked and stirred up frequently.

To determine which coal is adapted for a particular plant, most engineers will agree that it is good practice to sample and analyze all cargoes received. This procedure is proper to pursue in order that the purchaser may be assured that he is receiving coal of the quality he desires and it will determine whether or not the coal dealer is fulfilling his obligations. Simply knowing the B.t.u. value of the coal, however, is not an assurance that it is the coal wanted. To determine this it is necessary actually to burn the coal and carefully observe the evaporation of the boilers. It is preferable to make tests on all of the boilers, as merely trying the coal under one will not give general results. That these observations may be taken with any degree of accuracy, it is preferable to weigh the coal and use a meter of some kind in the boiler-feed line. If only the weight of the coal consumed had been determined, the economy can be checked quite closely by noting the wattmeter readings and obtaining the pounds of coal per kilowatt-hour. It is thus easy to determine the grade of fuel which will burn with the best economy in the plant, and all that remains to do is to analyze all coal of this grade that is received on any contract to make sure that the coal in each cargo is of the same quality.

The majority of engineers are not familiar with the sampling and the analysis of coal. It is generally considered that this is something beyond them and requiring the skill of a chemist. This is a wrong impression, as any engineer of ordinary intelligence can analyze his own coal. Two forms of analysis are made, one called the ultimate, which requires a chemist, as it determines all the different chemical elements. This is not of any great value to the engineer. The other form is the proximate analysis. This gives the percentages of volatile combustible, fixed carbon and ash, which are in fact the only elements which interest the average engineer, excepting sulphur, the percentage of which he can also easily obtain. All that are necessary to perform the proximate analysis are a platinum crucible, a set of balances, a bunsen burner and an assayer's muffle. As a general rule the coal dealer will be more careful in the selection of the coal if he is aware that an inspection is to be made.

Analysis of the flue gases must also be made. In plants of great magnitude the installation of a CO_2 recorder is the proper plan, but in smaller plants the management is generally adverse to the purchasing of expensive instruments. In this case the engineer can procure an Orsat apparatus, which is inexpensive and requires not a great amount of skill to operate. With this apparatus he can obtain the proper amount of air necessary to burn the coal economically and will get results which will enable him to increase his boiler efficiency.

There has been considerable agitation for the purchasing of coal on the B.t.u. basis, which is all right as far as it goes, but the best method is to find the proper coal and then contract for this particular grade and obtain it as long as possible, for generally if too many requisites are demanded for a particular coal the coal dealer will state his particular price, and in the end but little is gained.

Pipe Sizes Without Figures

By J. E. Bates

Frequently an inquiry or discussion is seen in the correspondence columns of mechanical journals as to how to get the proper size of a single pipe that will be required to carry the same volume as two or more pipes, and while it can be figured out very readily by getting the area of the pipes, there is a much quicker way of getting the same results which has the advantage of requiring no more knowledge than the ability to read correctly the figures on a rule.

Suppose there are an engine and pump to connect up and it is desired to know what size of pipe will be ample for both. Take a steel square or any true right angle and lay off the diameters of the pipes on the legs of the square; then measure across from the points representing these diameters, and this will be the diameter of pipe wanted.

Suppose the steam inlet to the engine is 3 inches and that on the pump 1½ inches; then the distance from the end of the 3-inch mark, Fig. 1, to the end of the 1½-inch mark would be about 3⅜ inches, which would mean the nearest commercial size, or a 3½-inch pipe. This is simply the solution of a right-angled triangle, in

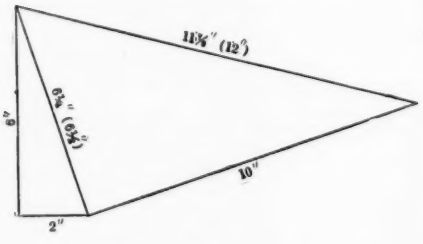


FIG. 4

which the diameter obtained is the hypotenuse.

Taking another case, suppose we have an engine with a 4-inch steam inlet, another engine with a 2½-inch steam inlet and a pump with a 1¼-inch inlet. Then a right-angled triangle, Fig. 2, with a base of 1¼ inches and a hight of 2½ inches, will have a hypotenuse about 2¾ inches long. Now take this resulting hypotenuse and use it as a base for another triangle, the hight of which will be equal to the inlet diameter of the other engine. The result obtained is 4⅞ inches, or a 5-inch pipe. This will mean that a 5-inch pipe will be run from the boiler to the 4-inch connection, a 3-inch pipe from there to the other engine, and a 1¼-inch pipe to the pump, assuming that the pump is farthest away from the boiler. If the engine with the 2½-inch opening is farthest from the boiler, the pump next and the engine with a 4-inch inlet nearest, it would require a 5-inch pipe from

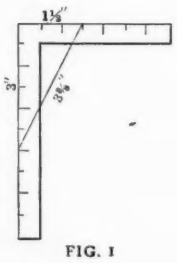


FIG. 1

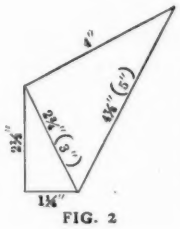


FIG. 2

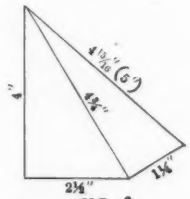


FIG. 3

the boiler to the 4-inch outlet, a 3-inch pipe on to the pump outlet and a 2½-inch to the other engine.

Taking it another way, if the engine with the 4-inch inlet was farthest from the boilers, the 2½-inch connection next and the pump nearest, the problem would be as represented in Fig. 3. In this event there would be a 5-inch pipe from the boilers to the smaller engine, with a 1¼-inch outlet to the pump and a 4-inch pipe on to the larger engine.

As a proof, the area of a pipe is the square of its diameter in inches times 0.7854, or to express it in a formula, where d represents diameter in inches, we have:

$$d^2 \times 0.7854 = A.$$

The area of an 1¼-inch pipe is 1.227 square inches; of a 2½-inch pipe, 4.908 square inches; of a 4-inch pipe, 12.566 square inches. The sum of these areas gives a total for the three pipes of 18.70 square inches. The area of a 5-inch pipe is 19.635 square inches, which is the nearest size.

Suppose the pipes are 10, 6 and 2 inches, respectively, the problem would work out as in Fig. 4, and a 12-inch pipe would be required. Reducing this to figures as a check, we obtain:

	Square Inches.
Area of 10-inch pipe	78.54
Area of 6-inch pipe	28.27
Area of 2-inch pipe	3.14
Total	109.95
Area of 12-inch pipe	113.10

To find the size of pipe required for any number of openings, begin at the opening farthest from the boiler and work toward the boiler. Suppose there are five different steam inlets to pipe to, which may be numbered 1, 2, 3, 4 and 5, No. 1 representing the opening nearest the boiler and the others numbering consecutively as to their relative distances from the boiler. For sizes take No. 1 to be 3½ inches in diameter; No. 2, 5 inches; No. 3, 2 inches; No. 4, 2½ inches; No. 5, 6 inches.

Beginning with opening No. 5 as the base and opening No. 4 as the hight, a hypotenuse of $6\frac{7}{16}$ inches is obtained. This would mean the use of a 6½-inch pipe between No. 3 and No. 4 openings, and a 6-inch pipe between No. 4 and No. 5 openings, the diameter of the opening farthest from the boiler always determining the size of the pipe to use between it and the next steam outlet. Taking the hypotenuse already obtained as a base, draw another triangle, the hight of which will be determined by the diameter of No. 3, or 2 inches. A resulting hypotenuse of 6¾ inches is obtained, and this means a 7-inch pipe between No. 2 and No. 3. Taking this last hypotenuse as a base and opening No. 2 for the hight, a hypotenuse of 8⅜ inches is obtained, or an 8½-inch pipe between No. 1 and No. 2 openings. With the hypotenuse last obtained as a base and No. 1 opening as the hight, the final resultant is $9\frac{1}{16}$ inches, which will determine the size of pipe to run between No. 1 opening and the boilers, or practically a 9-inch pipe.

By computation the following areas are obtained:

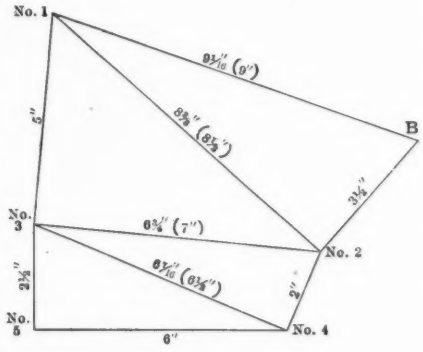


FIG. 5

	Square Inches.
Area of No. 1 pipe	9.621
Area of No. 2 pipe	19.635
Area of No. 3 pipe	3.142
Area of No. 4 pipe	4.908
Area of No. 5 pipe	28.274
Total area	65.580
Area of 9-inch pipe	63.617

This is within 1.963 square inches of what the figures call for, which is certainly near enough for all practical purposes.

Cylinder Ratios for Compound Engines

The accompanying table gives the cylinder ratios which in two-stage compounds will produce an equal division of the work between the two cylinders, with no drop or free expansion in the receiver. It considers only the ideal diagram, unaffected by clearance, wire drawing, compression, etc.

Find the total ratio of expansion in the first column. If not given, it may be found by dividing the initial by the terminal pressure, both absolute.

Divide the back pressure by the terminal pressure, both absolute, and find the quotient at the head of the columns. If the terminal pressure is not given it may be found by dividing the initial by the ratio of expansion.

In the column at the head of which the quotient of the back pressure divided by the terminal pressure is found, and in the line opposite the given ratio of expansion, will be found the cylinder ratio which will produce an equal division of the load as represented by the ideal diagram.

Example

What should be the ratio between the cylinder of a compound engine to work with an initial pressure of 120 pounds, absolute, ten expansions and exhaust against an absolute back pressure of 3 pounds, in order that the work may be equally divided between the cylinders?

The terminal pressure will be $120 \div 10 = 12$ pounds. The back pressure divided by the terminal is $3 \div 12 = 0.25$. Taking the value in the column under 0.25 and in the line opposite the given ratio, it is found that to produce an equal division of the ideal diagram the cylinder ratio should be 2.17.

The cylinder ratio naturally increases with the total ratio of expansion, and as the terminal approaches the back pressure. When the terminal becomes the same as the back pressure, i.e., when the low-pressure diagram ends in a point, the ratio of the cylinders becomes the square root of the total ratio of expansion as shown in the last column, where the quotient of the back pressure divided by the

Cylinder Ratios for Compound Engines, with Equal Distribution of Load.

Total Ratio of Expansion.	Quotient of Back Pressure Divided by Terminal Pressure, Both Absolute.																				
	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
6	1.52	1.56	1.60	1.64	1.68	1.73	1.77	1.81	1.86	1.91	1.96	2.05	2.06	2.11	2.16	2.22	2.27	2.33	2.38	2.45
	1.23	1.25	1.26	1.28	1.30	1.31	1.33	1.34	1.36	1.38	1.40	1.43	1.43	1.45	1.47	1.49	1.51	1.53	1.54	1.56
6.5	1.59	1.63	1.67	1.71	1.75	1.80	1.84	1.89	1.94	1.99	2.04	2.09	2.14	2.19	2.25	2.31	2.36	2.42	2.49	2.55
	1.26	1.28	1.29	1.31	1.32	1.34	1.36	1.37	1.39	1.41	1.43	1.44	1.46	1.48	1.50	1.52	1.54	1.55	1.58	1.60
7	1.64	1.69	1.73	1.77	1.82	1.86	1.91	1.96	2.01	2.06	2.12	2.17	2.22	2.28	2.33	2.39	2.45	2.52	2.58	2.65
	1.28	1.30	1.31	1.33	1.35	1.36	1.38	1.40	1.42	1.43	1.46	1.47	1.49	1.51	1.53	1.54	1.56	1.59	1.61	1.63
7.5	1.70	1.75	1.79	1.84	1.88	1.93	1.98	2.03	2.08	2.13	2.19	2.24	2.30	2.36	2.42	2.48	2.54	2.60	2.67	2.74
	1.30	1.32	1.34	1.36	1.37	1.39	1.41	1.42	1.44	1.46	1.48	1.50	1.52	1.54	1.55	1.57	1.59	1.61	1.63	1.65
8	1.76	1.81	1.85	1.90	1.94	1.99	2.04	2.09	2.15	2.20	2.26	2.31	2.37	2.43	2.50	2.56	2.62	2.69	2.76	2.83
	1.33	1.34	1.36	1.38	1.39	1.41	1.43	1.44	1.47	1.48	1.50	1.52	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.68
8.5	1.81	1.86	1.91	1.95	2.00	2.05	2.11	2.16	2.21	2.27	2.33	2.39	2.45	2.51	2.57	2.64	2.70	2.77	2.84	2.91
	1.34	1.36	1.38	1.40	1.41	1.43	1.45	1.47	1.49	1.51	1.53	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.68	1.70
9	1.87	1.91	1.96	2.01	2.06	2.11	2.17	2.22	2.28	2.34	2.40	2.46	2.52	2.58	2.65	2.71	2.78	2.85	2.93	3.00
	1.37	1.38	1.40	1.42	1.43	1.45	1.47	1.49	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73
9.5	1.92	1.96	2.01	2.07	2.12	2.17	2.23	2.28	2.34	2.40	2.46	2.52	2.59	2.65	2.72	2.79	2.86	2.93	3.01	3.08
	1.38	1.40	1.42	1.44	1.46	1.47	1.49	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75
10	1.97	2.02	2.07	2.12	2.17	2.23	2.28	2.34	2.40	2.46	2.52	2.59	2.65	2.72	2.79	2.86	2.93	3.01	3.08	3.16
	1.40	1.42	1.44	1.46	1.47	1.49	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.78
10.5	2 02	2.07	2.12	2.17	2.23	2.28	2.34	2.40	2.46	2.52	2.59	2.65	2.72	2.79	2.86	2.93	3.01	3.08	3.16	3.24
	1.42	1.44	1.46	1.47	1.49	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.78	1.80
11	2.06	2.11	2.17	2.22	2.28	2.34	2.40	2.46	2.52	2.58	2.65	2.71	2.78	2.85	2.93	3.00	3.08	3.15	3.23	3.32
	1.43	1.45	1.47	1.49	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.80	1.82
11.5	2.11	2.16	2.22	2.27	2.33	2.39	2.45	2.51	2.58	2.64	2.71	2.78	2.85	2.92	2.99	3.07	3.15	3.23	3.31	3.39
	1.45	1.47	1.49	1.51	1.53	1.54	1.56	1.58	1.61	1.62	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.80	1.82	1.84
12	2.15	2.21	2.26	2.32	2.38	2.44	2.50	2.57	2.63	2.70	2.77	2.84	2.91	2.98	3.06	3.13	3.21	3.29	3.38	3.46
	1.47	1.49	1.50	1.52	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.68	1.70	1.73	1.75	1.77	1.79	1.81	1.84	1.86
12.5	2.20	2.25	2.31	2.37	2.43	2.49	2.55	2.62	2.69	2.75	2.82	2.89	2.97	3.04	3.12	3.20	3.28	3.36	3.45	3.54
	1.48	1.50	1.52	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.68	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.86	1.88
13	2.24	2.30	2.36	2.42	2.48	2.54	2.60	2.67	2.74	2.81	2.88	2.95	3.03	3.10	3.18	3.26	3.34	3.43	3.52	3.60
	1.50	1.52	1.54	1.55	1.57	1.59	1.61	1.63	1.65	1.68	1.70	1.72	1.74	1 76	1.78	1.80	1.83	1.85	1.88	1.90
13.5	2.28	2.34	2.40	2.46	2.52	2.59	2.65	2.72	2.79	2.86	2.93	3.01	3.08	3.16	3.24	3.32	3.41	3.49	3.58	3.67
	1.51	1.53	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1 78	1.80	1.82	1.85	1.87	1.89	1.91
14	2.33	2.39	2.45	2.51	2.57	2.64	2.70	2.77	2.84	2.91	2.99	3.06	3.14	3.22	3.30	3.39	3.47	3.56	3.65	3.74
	1.53	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.68	1.70	1.73	1.75	1.77	1 79	1.82	1.84	1.86	1.89	1.91	1.93
14.5	2.37	2.43	2.49	2.55	2.62	2.68	2.75	2.82	2.89	2.96	3.04	3.12	3.20	3.28	3.36	3.44	3.53	3.62	3.71	3.81
	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.68	1.70	1.72	1.74	1.77	1.79	1 81	1.83	1.85	1.88	1.90	1.93	1.95
15	2.41	2.47	2.53	2.60	2.66	2.73	2.80	2.87	2.94	3.02	3.09	3.17	3.25	3 33	3.42	3.50	3.59	3.68	3.78	3.87
	1.55	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.74	1.76	1.78	1.80	1 82	1.85	1.87	1.89	1.92	1.94	1.97
15.5	2.45	2.51	2.57	2.64	2.70	2.77	2.84	2.92	2.99	3.07	3.14	3.22	3.30	3.39	3.47	3.56	3.65	3.74	3.84	3.94
	1.56	1.58	1.60	1.62	1.64	1.66	1.68	1.71	1.73	1.75	1.77	1.79	1.82	1 84	1.86	1.89	1.91	1.93	1.96	1.98
16	2.49	2.55	2.61	2.68	2.75	2.82	2.89	2.96	3.04	3.11	3.19	3.27	3.36	3.44	3.53	3.62	3.71	3.80	3.90	4.00
	1.58	1.60	1.61	1.64	1.66	1.68	1.70	1.72	1.74	1.76	1.79	1.81	1.83	1 85	1.88	1.90	1.93	1.95	1.97	2.00
16.5	2.53	2.59	2.65	2.72	2.79	2.86	2.93	3.01	3.08	3.16	3.24	3.32	3.41	3.50	3.58	3.67	3.77	3.86	3.96	4.06
	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.78	1.80	1.82	1.85	1.87	1.89	1.91	1.94	1.96	1.99	2.01
17	2.56	2.63	2.69	2.76	2.83	2.90	2.98	3.05	3.13	3.21	3.29	3.38	3.46	3.55	3.64	3.73	3.82	3.92	4.02	4.12
	1.60	1.62	1.64	1.66	1.68	1.70	1.73	1.75	1.77	1.79	1.81	1.84	1.86	1 88	1.91	1.93	1.95	1.98	2.00	2.03
17.5	2.60	2.67	2.73	2.80	2.87	2.95	3.02	3.10	3.18	3.26	3.34	3.42	3.51	3.60	3.69	3.78	3.88	3.98	4.08	4.18
	1.61	1.63	1.65	1.67	1.69	1.72	1.74	1.76	1.78	1.80	1.83	1.85	1.87	1.90	1.92	1.94	1.97	1.99	2.02	2.04
18	2.64	2.70	2.77	2.84	2.92	2.99	3.06	3.14	3.22	3.30	3.39	3.47	3.56	3.65	3.74	3.84	3.94	4.04	4.14	4.24
	1.62	1.64	1.66	1.68	1.71	1.73	1.75	1.77	1.79	1.82	1.84	1.86	1.89	1.91	1.93	1.96	1.98	2.01	2.03	2.06
18.5	2.67	2.74	2.81	2.88	2.96	3.03	3.11	3.19	3.27	3.35	3.43	3.52	3.61	3.70	3.79	3.89	3.99	4.09	4.19	4.30
	1.63	1.65	1.68	1.70	1.72	1.74	1.76	1.79	1.81	1.83	1.85	1.88	1.90	1.92	1.95	1.97	2.00	2.02	2.05	2.07
19	2.71	2.78	2.85	2.92	3.00	3.07	3.15	3.23	3.31	3.39	3.48	3.57	3.66	3.75	3.85	3.94	4.04	4.15	4.25	4.36
	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.80	1.82	1.84	1.86	1.89	1.91	1.94	1.96	1.98	2.01	2.04	2.06	2.09
19.5	2.75	2.81	2.89	2.96	3.03	3.11	3.19	3.27	3.35	3.44	3.53	3.61	3.71	3.80	3.90	3.99	4.10	4.20	4.31	4.41
	1.66	1.68	1.70	1.72	1.74	1.76	1.79	1.81	1.83	1.85	1.88	1.90	1.93	1.95	1.97	2.00	2.02	2.05	2.08	2.10
20	2.78	2.85	2.92	3.00	3.07	3.15	3.23	3.31	3.40	3.48	3.57	3.66	3.75	3.85	3.95	4.05	4.15	4.25	4.36	4.47
	1.67	1.69	1.71	1.73	1.75	1.77	1.80	1.82	1.84	1.86	1.89	1.91	1.94	1.96	1.99	2.01	2.04	2.06	2.09	2.11

terminal is unity. The values in the body of the table are the volumetric ratios; the volume of the low-pressure cylinder divided by the volume of the high-. The second row of figures give the ratios of cylinder diameters when the strokes are the same. For example, in an engine using 13 expansions and with a back pressure one-half the terminal, the low-pressure cylinder must have 2.81 times the volume and 1.68 times the diameter of the high-. The derivation of the formula by which the table was computed is given in another column.

Marine Engines

About the reciprocating marine engine there is absolutely nothing new to record. The manufacture of such engines has become as simple and monotonous as the weaving of calico. Attention has been concentrated on the turbine. The position, so far as marine propulsion as a whole stands, has been made quite clear. The turbine, to be efficient, drives the propeller too fast for it to be efficient, except for speeds over 18 knots. Either the turbine must be sacrificed to the propeller, or the propeller to the turbine. It has come to be fully understood that the economy of the turbine lies at the low-pressure end. In the reciprocating engine steam cannot, as a rule, be expanded much below 7 pounds absolute in the low-pressure cylinder. This cuts off a large section of the toe of the diagram. But the turbine can work down to 1½ pounds absolute. The result is that, instead of exhausting direct from the low-pressure cylinder into the condenser, it is worth while to interpose a turbine and exhaust through it to a condenser fitted with special auxiliary air extractors. This turbine may be of fairly large diameter running at a reasonable speed. Three screws are then used to propel the ship. This system of propulsion has been for some time under discussion, and has at last been put to the test on a large scale. The first merchant steamer to be fitted is the "Otaki," the property of the New Zealand Shipping Company, Limited, London. The vessel was built by W. Denny Brothers, and engined by Denny & Co., Limited, Dumbarton. The "Otaki" is fitted with two sets of reciprocating engines in the wings, driving twin screws; between these two engines is interposed a low-pressure turbine of very large size, which drives a center screw. The turbine revolves only in the ahead direction, and change valves are fitted so that the steam may be either passed directly into the condenser or to the turbine. Hence in maneuvering the vessel becomes an ordinary twin-screw. The twin-screw engines are triple-expansion of the ordinary design, 24½, 39 and 58 by 39. The "Otaki" is virtually a sister ship to the "Orari," which was built and delivered in 1906 to the same company. The boiler installation is precisely the same as in the "Orari." The only alteration that was made by the builders was that the length was slightly increased to make up for the loss due to the three tunnels, as against two in the "Orari," and the stern post was so arranged that the third screw could be fitted in an aperture. The dimensions of the "Otaki" are 464x60x34 feet, or 4 feet 6 inches longer than the "Orari." Otherwise the vessels are the same. The economical results seem to be very good. During the trial trip of the ship, which were made in November, the consumption of water for all purposes came out at 12.3 pounds per indicated horsepower per hour, a consumption probably the best ever attained at sea.

The purpose of the combination we have just described is the attainment of the economy of fuel. It has not been adapted to get over the speed-efficiency trouble. During the last year a radically different scheme has attracted a good deal of attention. It is to let the turbine run at that number of revolutions which best suits it, and the propeller at its best speed, the reconciliation of conflicting conditions being effected by the interposition of transmission gear of some kind. When the screw propeller was first introduced it was found that it would have to be run too fast for the slowly revolving steam engines of those days. Therefore gearing was introduced, the screw making two or three turns for each one of the crank shaft. Now we find the conditions reversed, and it has been proposed to drive the screw by spur gearing. The circumstances are more favorable than those just mentioned, because a pinion will drive a spur wheel with less loss of power, less friction and vibration, than a spur wheel will drive a pinion. But electricity provides a better way out of the difficulty. The turbine drives a dynamo at one speed, and that drives motors at a much lower speed. All the arguments in favor of this plan were very ably set forth by W. P. Durtnall to the Institute of Marine Engineers on July 2 and dealt with in our impressions for July 24 and November 6.

Superheating enjoys a strictly qualified popularity. Used in moderation it promotes economy without drawbacks. Attempts to use very hot steam, however, have not been commercially successful. It would occupy far more space than we can spare to set forth the reasons why in any detail. Great benefit is obtained by drying the steam thoroughly in the superheater, and raising its temperature about 100 degrees in the valve chest above that normal to the pressure. With such steam, and a pressure of 160 pounds, and clearance reduced to a minimum, an indicated horsepower may be had for a pound of good coal per hour, and this may be regarded as the most that can be obtained from any commercial kind of steam engine whatever.—*The Engineer*, London.

Gas Power as an Aid to Electrical Industries

By Philip W. Robson

Most of the generating stations in our smaller towns find it difficult to show satisfactory financial results. This is not a prejudiced statement, for though personally I have long felt its truth, I am able to quote a prominent electrical engineer as its author. I refer to J. F. C. Snell, who dealt fully with this aspect of the matter in his paper read in the early part of last year before the Institution of Electrical Engineers. On account of their unsatisfactory financial position, Mr. Snell actually advised the entire elimination of independent electricity stations in the smaller towns in favor of central plants each supplying groups of towns. This drastic step is not at all necessary if gas power is adopted in lieu of steam, and this opinion is the result of the frequent opportunities I have had of making careful comparison in the actual running costs of the best steam engines as against gas engines. I will give one characteristic example of a new slow-speed vertical-mill steam engine fitted with surface condenser and all the latest steam-saving appliances:

COMPARATIVE COSTS.

	Steam.	Gas.
Output of engine	250 I.H.P.	250 I.H.P.
Weekly working costs, 55 hours:		
Coal	£9 10 0	£ 0 0
Coke	0 0 0	3 0 0
Wages	2 1 6	2 0 0
Oil	1 5 0	0 6 0
Water	0 7 6	0 0 0
Sundries	0 15 2	0 5 9
	£13 19 2	£5 11 9
Weekly saving in favor of gas engines		8 7 5
Annual (52 weeks) saving in favor of gas engines		435 5 8

In the above comparison both the steam engine and the gas engine are assumed to work on constant load, but in the case of the fluctuating load which is usually experienced in a generating station, the comparative saving would be still more in favor of the gas-power plant, while the standby losses with the latter would be practically negligible. For such reasons it is not too much to say that the running costs of a small station driven by gas engines will be only one-third of the present costs with a steam plant. In addition, it is not to be forgotten that with a gas-engine combination there is no boiler, and consequently no smoke, and few ashes, besides which the plant can be got on full load within 30 minutes from starting with everything cold.

It is pleasant to record that during the year several gas engines have been ordered for use in such generating sta-

tions, and I do not doubt that experience will justify a great extension of their adoption. I believe that gas power will prove to be the salvation of small stations.

Large Units for Big Stations

The problem of large units is quite different. The large gas engine is still comparatively in its infancy, and the fiasco of the Johannesburg station is quite sufficient in itself to scare even bold minds from contemplating large gas units. Still progress is being maintained at a rapid rate, and an astonishing change of feeling has taken place in the year. In proof of this, the city of Birmingham is actually inviting proposals at the present time for 3000-kilowatt gas-driven sets. Confidence has been restored to a large extent by the organized visits which leading electrical engineers have paid to the Continent in the course of the year, when it was made possible for them to see many large engines successfully at work.

I think there is no doubt that the best types of large engine work well, and the fuel consumption is only about one-half that of the best large steam engines, but in connection with their adoption I would like, if I may do so without being misunderstood, to utter a word of warning. There are two chief factors in making a new prime mover a success: it must first be made right, and it must afterward be worked right. Both require special knowledge, and, speaking from experience as an engine maker, I am bound to admit that I very often find our engines better looked after by the station engineers and attendants than by our own men. I think other engine makers will bear me out in this, and after all one of the essential elements in the successful application of gas power on a big scale in central stations is that station engineers shall in all cases be educated up to them. With this object in view I advise in such cases that a moderate-sized engine and gas plant be first installed, say a unit of from 400 to 500 horsepower. This would always be a useful set to have; it could work quite as economically as the larger units, and further would be an experimental set to make all concerned acquainted with the general behavior and management of gas units. The transition from this first set to a subsequent larger unit would be so easy and natural that there would be a complete absence of administrative anxiety.

Let me again emphasize that it is one of the features of gas power that units of 200 horsepower will work quite as economically as those of 2000 horsepower, so that apart from space consideration there is not at present a great gain in adopting the larger units.

Steam Turbines versus Gas Engines

I am not aware of any reliable figures which will afford proper data for a comparison of the merits of the turbine with those of the large gas engine. There are frequently, however, special factors which must decide in favor of the latter. The turbine requires a high vacuum and consequently a lavish supply of cooling water for the condensing plant; the gas plant will work successfully with little water. Again, what is the cost of upkeep of these turbines? One hears rumors of the rapid disintegration of the blades, the renewal of which is a costly job, and there are many indications that the gas engine will not suffer from an upkeep comparison. Nor must it be forgotten that the only pressure in a gas-engine plant is that within the working cylinder. There are no high-pressure boilers, feed heaters, feed and steam pipes, and all the other high-pressure fittings which are necessary in a modern steam plant. The absence of these is an important advantage.

The Use of By-product Gases

There has been a great extension during the year in the use of gas engines in conjunction with blast-furnace and coke-oven gases, which are by-products of the great iron works and collieries. In the majority of cases these engines drive dynamos, and the works are accordingly equipped for electric drive. This sphere of development is going to prove a most valuable and important one, not less for electrical engineers than for gas-engine builders. There are many inquiries out at the present time for engines and dynamos for this class of work, a great deal of which will be carried out in the course of the new year.

Isolated Installations

The past year has witnessed a continuance of the use of gas power in isolated plants. Particular location has little or no influence on the successful and economical working of gas engines and gas producers, and it is to them that the electrical engineer must turn to enable him to produce electricity with economy in such cases, especially in view of the growing tendency which exists to remove factories out of the large town areas. In addition to factories, there are asylums, schools, and large country houses which are gradually adopting gas power for generating electricity.

Conflicting Interests

In those comparatively few districts where cheap current is available for power purposes from the public supply, a feeling of competition undoubtedly exists between those interested in the sale of smaller gas engines and producers, and the electric supply. Whether it is really economically sound for the latter to sell current to power users at a price which cannot be remunerative, is a controversial subject beyond the scope of these remarks. I would, however, like to remind the electrical industries that the use of electrical energy in all modern factories cannot be dispensed with, and hence if gas engines are put in, dynamos are also required. The electrical trades benefit therefore to at least an equal extent with the engine makers, and the attempts, often successful, which have been made in such cases to deprecate the use of gas engines, has also had the effect of shutting out an enormous number of moderate sized dynamos and other equipment, to the serious disadvantage of the electric trades. This should be specially noted at present when many of the latter are unfortunately in a most depressed condition.—*The Electrical Times,* London.

New Swedish Peat Invention

In stating that considerable money has been expended on Dartmoor and the Goss and Tregoss moors in England in attempts to convert peat into a marketable commodity on a large scale, Consul Joseph G Stephens writes from Plymouth of a present apparently successful invention:

The peat is employed on the moor and its immediate vicinity as fuel, but the various processes hitherto tried with a view to adapting it for use as a fuel in rivalry of coal in the towns, or for putting it to other useful purposes, have hitherto ended in large losses. A new method is, however, being put forward according to a local journal under which, it is claimed, peat may become a very valuable commodity. The inventor is a Swedish scientist, who has been engaged in experiments for years and has now reached the stage when a large factory plant has been put in operation.

The process is very simple. The peat, as obtained from the bog, is first of all pulped into a homogeneous mass. It is then heated under pressure to a temperature above 150 degrees Centigrade, after which the water is pressed out by mechanical means. The residue is formed into briquets in the usual way. It is because of the heating of the mass to so high a temperature that the peat ceases to hold water in the same way as at lower temperatures. By mechanical methods it is almost impossible to eliminate water from peat at ordinary temperatures, but by the process named the separation takes place quite easily. As to the comparative value of the peat briquet, it is claimed that 6 pounds will give as much heat as 4 or 5 pounds of good coal. It is said that the manufacture of fuel from peat by this process can be carried on uninterruptedly year in and year out, and that in the matter of price peat fuel would be much cheaper than coal.—*Monthly Consular and Trade Reports.*

The Technologic Branch of the United States Geological Survey is issuing, upon application, a copy of Ringlemann's chart for grading the density of smoke.

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Visiting

The engineer who has frequent opportunities to visit other plants than his own possesses a material advantage. To see other makes and types of apparatus, to exchange ideas with other engineers regarding methods and results, to discuss difficulties and swap experiences, can but make a man broader, better informed and capable of greater things.

Comparatively few engineers are so favored. The activity of the ordinary member of the craft is confined to a small sphere, and the condition that he shall be constantly within it is imperative. When he does get a day off he is naturally more inclined to spend it in some other way than in visiting other plants. And yet there are evenings when one might drop in at the power house or the electric-light station or some of the hotel and other plants which run at night.

Have you exhausted the possibilities for information of all the plants in your neighborhood?

Have you noticed that it is the man who devotes some of his spare time to visiting around in this way who gets on, and who is looked up to and sought when something of importance is up?

The next best thing to visiting oneself is being visited. An intelligent and interested caller can be made a fertile source of information, and in return for your courtesies to him will gladly be drawn upon for any knowledge which he may possess about the things in which you are especially interested. The men who knew two or three things about engineering and hugged them to themselves, have been swept aside (they never were engineers) by men who by a free exchange of knowledge have learned more in weeks than the niggards would acquire in a lifetime.

And finally for the man who has neither the chance to make visits to nor receive visits from his kind there is the weekly or monthly arrival of his technical paper. Here he will find accounts of the visits of the editors to different remarkable and interesting plants. Photographs of the different features of the plant will be reproduced, so that the reader who follows the article closely and intelligently may know how the plant looks and how it is put together almost as well as though he had been over it himself. These articles are not simple enumerations and catalog descriptions of the proprietary articles and machinery which go to make up a power plant, but seek to answer the questions that an intelligent engineer would ask and to point out the things which would interest and attract him if he were visiting the plant himself. In your paper also those who have had exceptional opportunities for observation or have devoted study and thought to some particular subject come to talk to you upon the things with which they are especially qualified to deal, and if you do not catch their meaning and require some point straightened out, they or the editors are always glad to be called upon for an explanation. If you do not agree with them, there are the correspondence columns where you can argue it out with them and other contributors to your own satisfaction, besides making a little cigar or book money by your trouble.

The next time you have a caller, try to make it worth his while to have called, and do not let him go until you have profited by all that he is able and willing to tell you.

And the next time your paper comes see if you have been getting out of it all the good which it is capable and willing to do you.

Failure of a Butt Joint

On another page of this issue will be found a description of the failure of a triple-riveted butt double-strapped boiler seam. (Two other similar cases are known to the writer of the article.) From the description of this failure it would appear that it was caused by an action similar to that supposed to produce a like defect in the lap form of seam. It has generally been assumed that this defect in the lap seam was caused by the ends of the sheets being out of line, and the circumferential stresses produced by internal pressure causing the plates to bend along the outer line of rivet heads, this action being repeated with each change or pulsation in the steam pressure.

While this explanation is doubtless in the main correct, it does not explain why these lap cracks invariably start on the under side of the outer lapping sheet and never on the top of the under lapping sheet. As far as the foregoing theory of their formation is concerned, they should be as likely to occur on one side of the lap as the other. It is not impossible that the form of the seam is not the only factor to be held responsible when failure occurs to a lap joint.

While the record of a single failure of the butt form of joint would not justify speculation as to the probability of other failures of a similar character, it does not require a great stretch of the imagination to picture this type of joint being made so that the true cylindrical form of the boiler would not be maintained at the joint, and as a consequence bending of the sheet might take place in operation.

It has been previously suggested in these columns that there is an apparent need for further investigation of riveted joints and it would seem that there is an interesting and profitable field of investigation open to some institution of learning, to determine by actual experiment on boilers under pressure just how deformation occurs at the seams when made true to form and otherwise.

The State of Massachusetts is spending, directly and indirectly, a vast sum of money annually in an endeavor to insure as far as possible that steam boilers in its bounds be immune from explosion. Why would not a careful investigation of what actually happens to boiler joints under working conditions be of advantage in accomplishing the desired result?

If maintaining the true cylindrical form of the shell at a butt-strapped seam is of equal importance to the type of joint in rendering it safe for continued use, the sooner the facts are known the better. Safety of boiler construction is of the greatest importance to the public, and no feature should be guessed at or surmised that will admit of direct proof by experiment. The number of extremely dangerous cracks that have recently been discovered in boilers, before they have actually caused explosions, would seem to point to a need for a periodical examination of old boilers under hydrostatic pressure, with all the longitudinal seams uncovered so that every facility may be afforded to detect such defects.

The fact that the boiler did not explode is evidently due to the fact that the sheet, although split nearly across, was retained in position by being riveted to the flange of the head on one side and to the sound sheet on the other.

The Actual Cost of Power

In the great majority of cases where power costs are figured from the records of operating plants, the total expense per horsepower or per kilowatt-hour is calculated without taking into account the fixed charges of the installation. It is usually sufficient from the point of view of the plant operator to determine what his power costs him month by month, as manufactured under the local conditions of his station. He can ordinarily do little or nothing to reduce the fixed charges, except by properly maintaining the plant to offset its depreciation; the operating costs, pure and simple, are the facts he must deal with, and upon which he must base his work in the interests of economical production.

It is important for the engineer to be able to figure power costs including the fixed charges, however, when occasion arises, and to appreciate the influence of the annual interest, depreciation, insurance and taxes on the unit cost of power produced. It is evident that the greater the output that can be obtained in a plant, the less will be the fixed or annual charges per unit. In some cases these charges are quite high, in others low. An example of what power actually costs in a modern oil-engine station in the past year may be cited. This station contained two American Diesel engines of 225 horsepower each, with triple 16x24-inch cylinders, direct-connected to alternators running 164 revolutions per minute.

The total cost of the station was about $105,000, or $234 per horsepower of normal rating. The manufacturing cost in the plant was made up of the following items: Fuel oil, $3400; water, $88; oil and waste, $347; wages, $3613; station repairs, $5; oil-plant repairs, $663; electric-plant repairs, $13; total, $8129. The energy delivered at the switchboard was 817,000 kilowatt-hours. The operating cost was thus about 1 cent per kilowatt-hour. The total cost of the power, however, included the interest on the initial cost of the plant, assumed as six per cent.; depreciation, taken at seven per cent.; taxes, one per cent.; insurance, one per cent.; total fixed charges, fifteen per cent. The plant cost was made up of: Building, $39,288; real estate, $17,957; oil palnt, $38,500 ($85.50 per horsepower); electric plant, $9500. The total fixed charges were, therefore, fifteen per cent. of $105,000, or about $15,700 per year. The manufacturing cost at the station per kilowatt-hour figures about half the fixed charges per kilowatt-hour, the latter coming to about 1.92 cents. Thus the total cost of producing power in this plant is not far from 2.92 cents per unit generated, and the influence of the initial investment in the station becomes clearly important.

In making the choice of station equipment, it is, of course, necessary to consider the features of operating convenience and reliability, safety, probability of heavy repairs, overload capacity, the reliability of the makers, the accessibility of the equipment for repairs and adjustment and similar points, in addition to the simple question of cost. The economy of production may be excellent, as in the case illustrated, on oil costing from 3 to 4 cents per gallon; the repairs are far from alarming, also; but the initial cost of the station is high. It must be borne in mind, in considering a case of this kind, that the load factor of the plant exerts a powerful influence on the ultimate economy of production. The output of the station for the year was about one-third its maximum possible output for a three-hundred-day year at full load for twenty-four hours. If the company succeeds in increasing the load on the plant, the cost per kilowatt-hour due to the fixed charges will rapidly go down. If the plant could be operated at full load for every business day of the year, doubtless impracticable under its local conditions, but sometimes feasible with electrochemical loads, the fixed cost per kilowatt-hour would drop to about 0.7 cent, and it is probable that a load nearer the machinery rating would result in still better fuel economy, probably carrying the total cost of power production down to 1.5 cents at the most.

A moderate initial cost of plant is exceedingly important if it can be obtained, but in cases where it is high, it will not do to assume that it will not pay to install expensive apparatus, provided the operating economy and service reliability are all that could be desired. The point is, not to overlook the fixed charges in making estimates of the value of different equipments.

Furnace Arches

It has been said, and rightly, that in the future the greatest economy to be made in the steam plant will be in the boiler room rather than in the engines, which have arrived at a fair state of perfection. Stress has lately been laid upon the matter of preserving the coal supply, but even casting aside the fact that this is desirable, the standpoint of economy in dollars and cents demands not only that the furnace of a boiler shall be constructed so that the fuel will be burned to the best advantage, but that a low grade of cheap fuel can be burned successfully.

That the dutch-oven furnace is the best type, as far as known, is a matter of fact, and that it has not become more popular is not that its merits have not been recognized, but that in most cases the necessary space for its installation is lacking. The dutch-oven furnace is efficient because in it the gases are heated to a temperature sufficient to cause their consumption before reaching the cooling surfaces of the boiler tubes or shell, as the case may be; the top of the dutch oven, which is constructed of firebrick, bringing about this result. This idea is being carried out in the shape of brick arches in the ordinary furnace, which gives the same economical result regarding the consumption of gases freed from the fuel.

The brick arch is a fuel saver not only because it consumes the gases liberated from the coal, but because it produces a longer flame than obtains in furnaces not so designed, thus making the heating surface of the boiler more efficient. A furnace having the lowest temperature will have the highest amount of CO, due to imperfect combustion, and tests have been made with furnaces with and without the firebrick arch which have resulted in a saving of more than fourteen per cent. in CO over the furnace not fitted with the brick arch.

The matter of burning the smaller sizes of coal is becoming of considerable importance and the brick arch plays no small part in its consumption, especially in cities where a smoke ordinance prohibits the making of smoke to any great extent.

It is necessary to take into consideration that the first loss in the power-producing process occurs in the furnace, to the tune of about twenty-odd per cent. This includes the heat escaping out of the stack, radiation from the boiler and setting, which may be greatly varied depending upon the manner in which the brickwork is kept in repair, and the loss due to coal which drops through the grates into the ashpit.

Coal and Coke Production in the United States

The following table has been compiled largely from data communicated by the several State mine inspectors, estimates having been made only where no such statistics were available, but in all cases upon the basis of good information:

PRODUCTION OF COAL IN THE UNITED STATES.

States.	1907. Short Tons.	1908. Short Tons.
Bituminous:		
Alabama	14,417,863	11,950,000
Arkansas	1,930,400	1,750,000
California and Alaska	45,300	55,000
Colorado	10,920,527	9,773,000
Georgia and North Carolina	365,300	275,000
Illinois	(c)51,317,146	48,000,000
Indiana	11,692,072	12,000,000
Iowa	(a) 7,568,424	7,050,000
Kansas	6,137,040	5,600,000
Kentucky	10,207,060	9,526,000
Maryland	5,529,663	5,000,000
Michigan	(b) 1,898,446	2,000,000
Missouri	4,350,000	3,900,000
Montana	1,810,000	1,800,000
New Mexico	(a) 2,302,062	2,725,000
North Dakota	268,300	250,000
Ohio	32,465,949	30,000,000
Oklahoma	3,450,000	3,250,000
Oregon	51,600	25,000
Pennsylvania	149,759,089	118,309,000
Tennessee	6,760,017	5,009,000
Texas	1,300,000	1,250,000
Utah	1,967,621	2,000,000
Virginia	4,570,341	4,000,000
Washington	3,713,824	3,000,000
West Virginia	47,205,965	44,091,000
Wyoming	6,218,859	6,100,000
Total bituminous	388,222,868	338,688,000
Anthracite:		
Colorado	45,113	30,000
New Mexico	17,000	10,000
Pennsylvania	86,279,719	80,240,000
Total anthracite	86,341,832	80,280,000
Grand total	474,564,700	418,968,000

(a) For the fiscal year ending June 30.
(b) For the 12 months ending November 30, 1907.
(c) As reported by the U. S. Geological Survey

PRODUCTION OF COKE IN THE UNITED STATES.

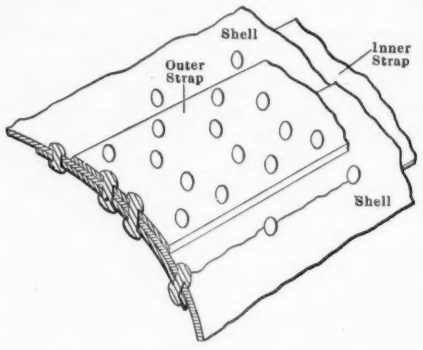
States.	1907. Short Tons.	1908. Short Tons.
Alabama	3,096,722	2,800,000
Colorado	1,097,051	854,000
Georgia and North Carolina	71,460	70,000
Illinois	372,697	270,000
Kentucky	77,055	60,000
Montana	31,400	30,000
New Mexico	203,437	260,000
Ohio	310,640	250,000
Oklahoma	57,600	50,000
Pennsylvania	23,516,309	11,287,000
Tennessee	495,200	250,000
Utah	324,692	290,000
Virginia	1,622,734	1,200,000
Washington	61,400	48,000
West Virginia	4,078,222	2,978,000
Other states (c)	1,650,000	2,000,000
Total	37,066,619	22,697,000

(c) Includes output of by-product coke for Massachusetts, Maryland, Minnesota, New York, Michigan, Wisconsin, New Jersey.

If the production of coal in 1908 had shown as large an increase as in 1907, the long predicted half-billion total would have been reached. To satisfy our fuel demands during the last 12 months, we have exhausted about 61 square miles of our available coal lands. If our production should remain stationary, at this total, in future years, it would require over 6000 years to exhaust our coal beds; if, however, the future production should increase at a rate equal to that shown in 1907, the available coal seams would last only about 200 years.—*Engineering and Mining Journal.*

Hidden Crack in a Strapped Butt Joint

The triple-riveted butt-strapped joint has been assumed to be a complete remedy for the hidden crack to which the lap joint is liable. The following account of the failure of a butt joint in this manner will, therefore, be of exceptional interest. It is written by T. T. Parker, chief boiler inspector of the Fidelity and Casualty Insurance Company, and will appear in the bulletin issued by that company. Mr. Parker says that this is the third instance of the kind which has come to his attention:



WHERE THE FAILURE OCCURRED

A recent failure of a horizontal tubular boiler by rupture through the double pitch of rivet line of the longitudinal seam is of more than usual interest. The boiler was 72 inches in diameter and of $\frac{7}{16}$-inch shell plate. It was about sixteen years old. The inner and outer straps were each $\frac{3}{8}$ inch thick. The joint was triple-riveted, the single pitch being 3⅜-inch, the double 6¾-inch and the rivet holes $\frac{15}{16}$-inch. This represents standard practice for this thickness of plate and the calculated efficiency of the joint is 86 per cent. of the solid plate, the weakest section of the joint being the net plate in the double pitch or outer row of rivets, at which point the failure occurred.

The boiler had been cut out and thoroughly cleaned and steam had been raised to 80 pounds preparatory to cutting the boiler in with others, when the engineer noted steam escaping through the brickwork at the rear sheet on top. Removing some of the brickwork disclosed a crack extending for five rivets, a distance of 33¾ inches, the rupture being from $\frac{1}{16}$-inch to ⅛-inch. The main valve had not been opened. The engineer quietly pulled the fire and, pumping up, reduced the pressure to zero.

The removal of the straps resulted in finding the plate cracked on the inside from rivet to rivet from the rear-head seam to the circular seam. This condition, of course, had been hidden by the inside strap and was not revealed until the crack had broken through and leaked. The rivet holes had been punched and the burs were not removed. There were slight marks in the plate along the double-pitch line, indicating the usual bending action when the sheet entered the cold rolls. The plate at the fracture was full size and showed no reduction in area, which is significant of segregation of carbon at the end of the sheet.

Multiplying the 80 pounds pressure by the radius gives a pressure of 2880 pounds per square inch on the shell. This multiplied by 33 inches gives 95,040 pounds on a strip the length of the fracture. According to all calculations this condition should have resulted in a terrible explosion, as there was nothing to hold the ruptured sides of the sheet together save the frictional resistance of the rivet heads to the severed plate. It is impossible to determine how long the crack existed under the strap prior to showing through the sheet, but there is no doubt it first started from the inner side and worked outwardly. Had the boiler been made with lap seams unquestionably an explosion would have occurred, as the strength of the inner strap in connection with the frictional value of the rivets on this strap would have been lacking. The accident leads one to believe that a test piece should be cut from *each end* of *each sheet* and subjected to the usual chemical and physical requirements, and that the rivet holes in such seams, if punched, should be reamed out at least ¼ of an inch, with a view to removing the evil effects of the punch.

The conduct of the engineer in charge was truly admirable. First, there was his carefulness in noting and examining the defect; second, his courage in staying with the boiler (a dynamite bomb with the fuse burning) until the pressure had been carefully removed. Such devotion to duty in the moment of danger stamps the engineer as a hero in the highest degree and reflects great credit on the profession.

The entire sheet was condemned, of course, and a new boiler was ordered.

The twenty-fourth anniversary of Newark Association No. 3, N. A. S. E., will be held at the new Auditorium, 81 and 83 Orange street, Newark, N. J., February 12 next.

The next meeting of the National Gas and Gasolene Engine Trades Association will be held at the Auditorium hotel, Chicago, Tuesday, February 9.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Center Crank and Crosshead Pin Oiler

The accompanying illustration, Fig. 1, represents a device for oiling the crank pin of a high-speed center-crank engine. It is manufactured by William W. Nugent & Co., 18 to 30 West Randolph street, Chicago. The object of this oiler is to provide a continuous tube from a stationary oil supply to the crank pin when the engine is in motion. The tubes telescope and are self-lubricating.

Fig. 2 shows a method of oiling a center crank and crosshead pin on a vertical trunk engine, such as vertical gas engines, etc. The oil is fed under pressure and must go to the parts to be oiled. This device will stand high speeds.

The illustrations show how the oil is distributed to the parts to be oiled by means of the Nugent steel oil-tight knuckle joints. This method prevents short-circuiting of generators, in direct-connected units, due to splashing oil, and the danger from trouble in the brasses, due to grit, is eliminated almost entirely.

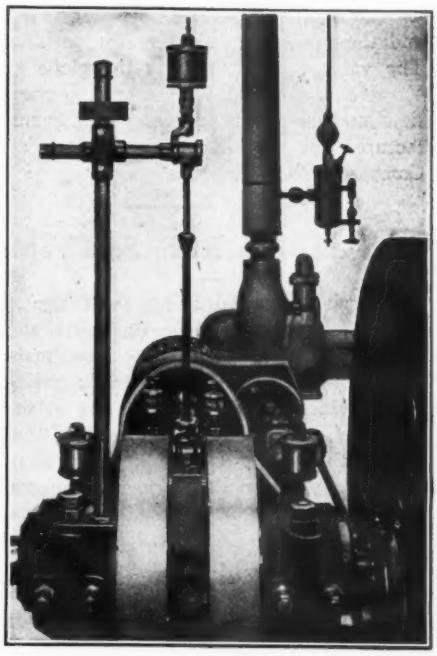


FIG. 1. THE NUGENT CRANK-PIN OILER

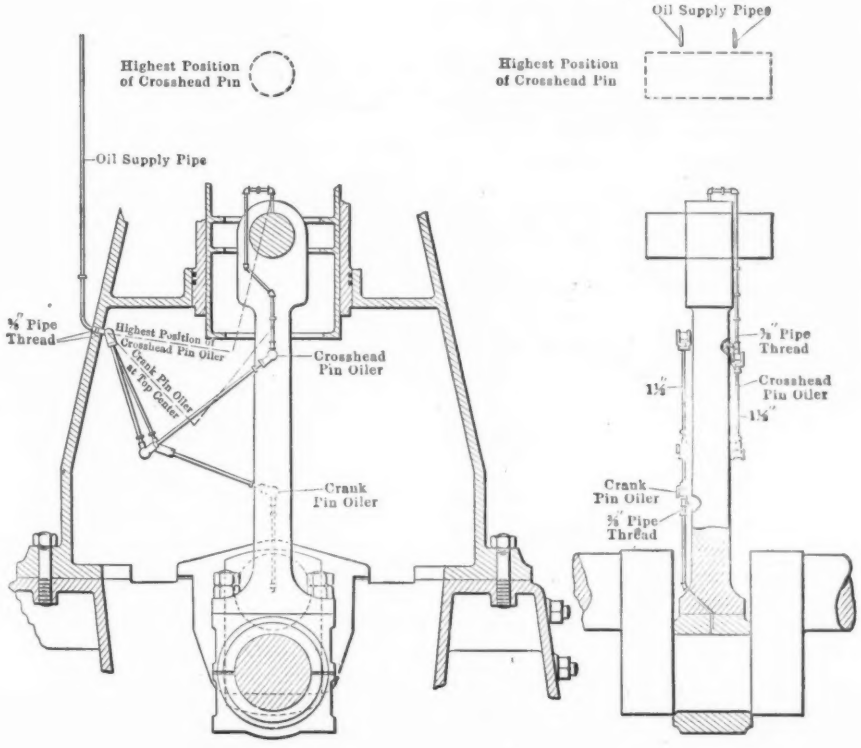


FIG. 2. DETAILS OF CRANK-PIN OILER

Simplex Blowoff Valve

In Fig. 1 is shown the extension of a valve without a seat or a tapered plug, known as the Simplex blowoff valve.

The sectional drawings, Figs. 2 and 3, show the interior construction of this valve in open and closed positions. The two sets of packing rings *P*, Fig. 2, surround the plug valve *V*, and are compressed when the valve comes to a closed

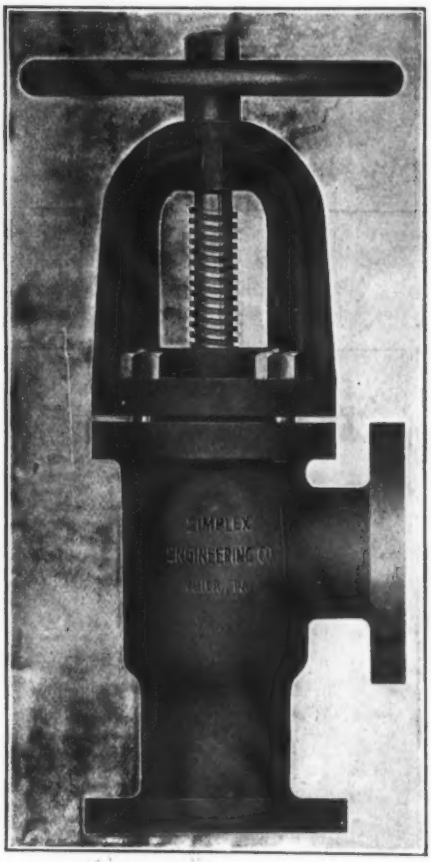


FIG. 1

position, thereby insuring a tight valve. The packing can be made to take up the leakage around plug valve *V* by merely operating the handwheel which revolves the spindle running in the hollow portion of the valve.

The valve plug is prevented from turning by guides in the yoke, and the packing is compressed by the projecting flange on the plug valve. When opening the valve this slight compression is removed from the packing, allowing a free and

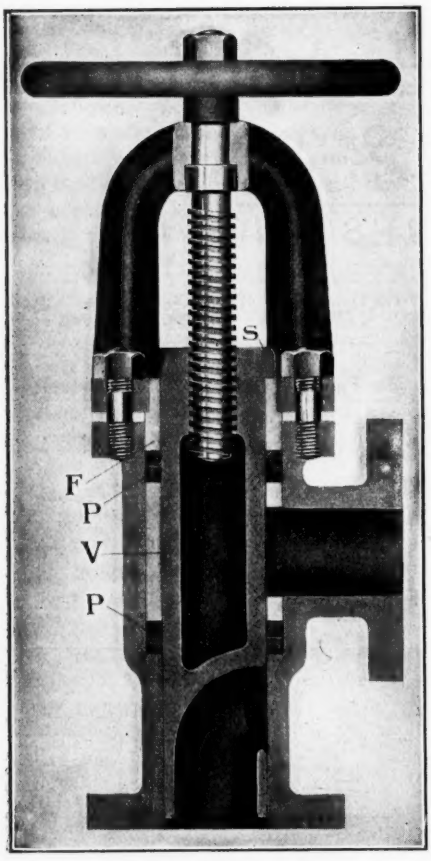


FIG. 2

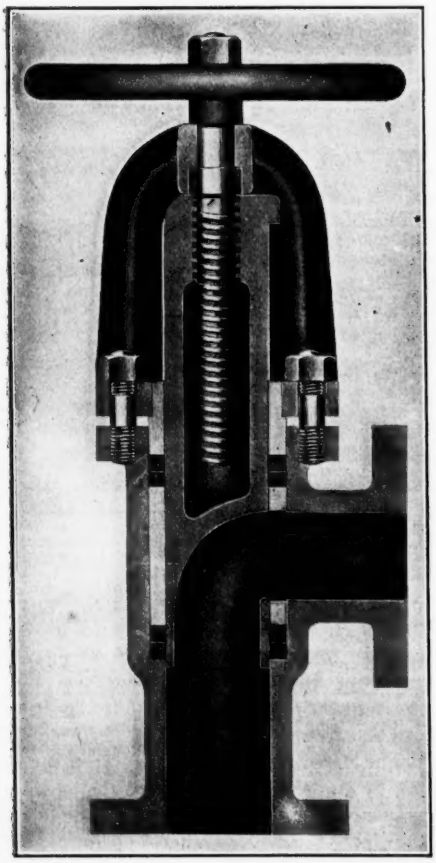


FIG. 3

easy movement to the valve, at the same time reducing the wear and tear on the packing, giving a free, unrestricted blow-out through the port (which is curved). See Fig. 3. This removes severe strains from the valve body.

The valve has no seat nor projection on which scale, sediment, etc., can accumulate, in either the closed or open position. The operation of the plug valve *V* is exposed to view, as well as the means of preventing the rotation of the plug valve, and the means of adjusting the packing. The valve is also made in the globe or Y-valve shape and with special connections and flanges as ordered. It is manufactured by the Simplex Engineering Company, Philadelphia, Penn.

Emergency Non-return Stop Valve

Referring to the drawing, the flange *A* is attached to the nozzle of the boiler, and the flange *B* is attached to the main steam line. The seat *C* has an extending flange which fits in a groove cut in the flange *A*, and the lower face, fitting against the flange of the boiler, is held in position by the bolts *D*, to prevent the seat from working loose. No screw threads are employed to hold the seat in position, therefore it is easy to remove. The method of guiding the valve disk *E* on the long stem held in position to the valve seat *C* dispenses with the stem projecting from the valve, and is also intended to assist in preventing hammering and chattering of the disk. Also, attached to the valve disk *E* is a piston *F* provided with piston rings *G* which take up the wear inside the dashpot *H*. A drain is provided to remove the water of condensation which might collect on top of the valve seat.

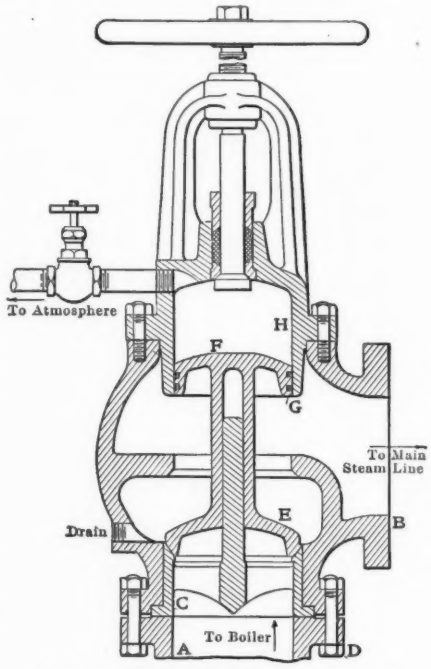
When attached to the boiler and steam header, with the stem and handwheel opened full, the valve is in operation, subject to the conditions existing in the pipes to which the valve is attached. With the main header pressure 150 pounds, the valve disk *E* is expected to remain on the seat *C* until the individual boiler has attained a pressure of 150 pounds, or the same pressure as the header, before steam can pass into the header. This feature points out a lazy boiler, so that one boiler cannot have the pressure of all the other boilers when the individual boiler pressure drops.

The opening and closing of the valve being subject to the pressures above and below the valve disk *E*, the valve cannot be opened into a boiler out of use, in which men may be working. Should a tube blow out in an individual boiler, that boiler alone is crippled, as the valve disk *E* closes on its lower seat automatically by the drop in pressure.

When desiring to discontinue using a boiler it is only necessary to stop firing and the valve will close without hand manipulation. To insure the certainty of the valve being closed, the handwheel to which the stem is attached is screwed down its full stroke.

In the event of a header explosion, the valve disk *E* is thrown wide open on account of the drop in the steam pressure on the header or outlet of the valve and, coming in contact with the upper seat in the valve body, shuts off the steam flow from each boiler to which this valve is attached.

If an accident to the engines occurs this valve may be closed from a distance by opening the small pilot valve which releases the steam on the upper piston and allows the boiler pressure beneath the valve disk *E* to close the valve against the upper seat without manipulating the hand-



EMERGENCY NON-RETURN STOP VALVE

wheel. It will be noted this valve has but one moving part, a valve disk to which is attached a piston. It is manufactured by John V. Schmid, 1823 West Allegheny avenue, Philadelphia, Penn.

Personal

J. E. Woodwell, of L. B. Marks & J. E. Woodwell, New York City, has been retained by McKim, Mead & White, architects, as consulting engineer for the entire mechanical and electrical equipment, including the heating and ventilation, electric lighting and power, mail-handling devices, etc., of the new United States post office to be erected at the Pennsylvania terminal station in New York City. The cost of this installation will be upward of $500,000. The firm has retained Prof. S. H. Woodbridge, of the Massachusetts Institute of Technology, as associate consulting engineer for the heating and ventilation of this building.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Comparative Evaporative Power

In J. G. McIntosh's book, "Technology of Sugar," I find the following paragraph: "The comparative evaporative power is not increased by adding more units (in speaking of double and triple effects)." Will a quadruple effect cut in two double effects give nearly double evaporation? If a plantation has a standard double effect and adds to it another cell, making it a triple effect, will this increase its capacity for evaporation, or will it be better to run the third cell as a single effect to be able to evaporate more liquid?

E. H.

Compared with the compound or triple-expansion engine, if the evaporating conditions are analogous to comparing the power capable of being developed by the whole three cylinders of a triple engine to the power capable of being developed by the low-pressure cylinder, the paragraph quoted is right, as the low-pressure cylinder with the same initial pressure will easily develop the same power as the whole three, but with less economy of steam. In the triple-effect evaporator the economy of steam will be greater when compared with single effect than it will be in a triple engine compared with a good single engine, and the economy will be due to a different principle than that of the triple engine.

Any one of the units of a triple-effect system of evaporators will evaporate the same quantity per hour as the whole three units, provided the initial steam pressure and the vacuum in the condenser are the same when used single or triple, but, of course, there will be three times as much steam used in the single effect.

Quadruple effects cut into two double effects will give double the quantity of evaporation, provided the pressure of steam in the two first effects of the two doubles is the same as that in the first effect of the quadruple (vacuum in the condenser must, of course, be the same in either case). As triple effects are ordinarily designed, the comparatively large amount of heating surface in each unit prevents them being used to their full capacity as single effects, for if the full steam pressure were used on a single unit, that is, used on the first of the whole three, the single unit would prime or foam to such extent that much valuable concentrate would be lost by entrainment.

Of course, triple effects could be designed with a smaller quantity of heating surface in proportion to the volume of the evaporator, so that the entrainment would be small when used as single effects.

With the same amount of heating surface in the new as in one unit of the double effects, it will not increase the evaporating capacity unless the steam pressure is also increased; although adding a larger third unit to the two units would somewhat increase the capacity, provided the larger unit is used to evaporate the heavier or more concentrated liquor, which circulates with more difficulty and therefore needs more heating surface for a given rate of evaporation.

Run as a single effect to get the most liquor evaporated where economy of steam does not count.

By separating the two units of the double and making two singles, there is no need of installing another new one, provided economy is no object and foaming does not result.

Book Reviews

SHAFTING, PULLEYS, BELTING AND ROPE TRANSMISSION. By Hubert E. Collins. Hill Publishing Company, New York. Cloth; 157 pages, 4½x7 inches; illustrated. Price, $1.50.

This is another of the POWER handbooks, made up largely of material which has appeared in the columns of POWER, and has thus had the advantage of previous presentation, discussion and revision. It contains practical directions for the putting up, lining and leveling, and the care and maintenance of shafting, belting and rope transmissions, splicing of ropes and belts, etc. It treats the subject from the practical rather than the academic standpoint and should furnish the man who uses it hints which will be worth many times its cost.

MODERN POWER GAS PRODUCER PRACTICE. By Horace Allen. The Technical Publishing Company, Ltd., London, Eng. Cloth; 233 pages, 5x7 inches; 136 illustrations. Price, $2.50.

This little work is one of the most satisfying that the reviewer has ever read. With the exception of some typographical slips, left in doubtless by careless proofreading, there are no inaccuracies that are discernible from reading the text without a sliderule—and the reviewer has not skipped a paragraph. The names of Benier and Theisen are spelled "Bernier" and "Thiesen," the second table on page 243 is not arranged so as to be intelligible at first glance, the material forming the basis of the book is rather overwhelmingly British and the discussion of coals is disproportionately limited. Beyond these few blemishes the book is highly commendable. The author knows his subject thoroughly and knows how to tell the reader about it; his style is simple and clear, his English most excellent and his sequence of subjects logical and "leading." The book should be heartily welcomed by everyone interested in the subject.

BOILERS. By Hubert E. Collins. Hill Publishing Company, New York. Cloth; 196 pages, 4½x7 inches; illustrated. Price, $1.

This book, which is one of the POWER handbook series and was compiled largely from POWER AND THE ENGINEER, starts with a description of what goes on in a boiler as seen by watching a glass model of a water-tube type. Then follow simple talks on the Efficiency of Riveted Joints; the Bursting Strength of Boilers; the Bracing of Horizontal Tubular Boilers; Directions for Calculating the Strength of Riveted Joints and for Finding the Area to be Braced in Boiler Heads; a Graphical Determination of Boiler Dimensions; the Safety Valve; Horsepower of Boilers; Boiler Appliances; Care and Management of Boilers; Setting Return-Tubular Boilers; Renewing Boiler Tubes; Use of Wood; Boiler Rules; and Mechanical Tube Cleaners. The presentation is in the simple style which has made the matter popular with practical men as it has appeared in our pages from time to time.

Books Received

"The Girl and the Motor." By Hilda Ward. The Gas Engine Publishing Company, Cincinnati, O. Cloth; 111 pages, 4½x7 inches; illustrated. Price, $1.

"Oil Motors." By G. Lieckfeld. J. B. Lippincott Company, Philadelphia, Penn. Morocco; 272 pages, 6x9 inches; 306 illustrations; indexed. Price, $4.50.

"The Design and Construction of Ships." By John Harvard Biles. J. B. Lippincott Company, Philadelphia, Penn. Morocco; 423 pages, 6x8¾ inches; 245 illustrations; 36 folding plates; tables; indexed. Price, $7.50.

Personal

F. E. Ransley, widely known representative of Greene, Tweed & Co., manufacturers of "Palmetto" packing, was recently appointed assistant manager of the company, with headquarters at 226 Lake street, Chicago, Ill.

Business Items

The Southern branch of the American Steam Gauge and Valve Manufacturing Company, for several years located in the Equitable building, Atlanta, Ga., has been removed to 524 and 525 Candler building, that city.

One of the novel features of the electrical show at Chicago, January 16 to 30, inclusive, is the Northern exhibit, where a Northern electric rock drill is publicly demonstrated. In addition the new Northern type S motor is shown in operation. A type S grinder and buffer are also on view.

The Parker Boiler Company, of Philadelphia, has secured orders for one 153-horse-

power boiler for the Pilgrim Laundry Company, of Philadelphia, two 122-horsepower boilers for the Southern Pacific hospital at San Francisco, and two 234-horsepower boilers for George W. Clayton College, Denver, Colo.

The Power Specialty Company, 111 Broadway, New York, builder of the Foster superheater and Heenan refuse destructors, recently received orders for 16,500 horsepower of superheaters, including those placed in boilers and separately fired units. They have also just been advised that the proposal to the city of Portsmouth, England, covering two Heenan destructors, each of 100 tons daily capacity, has been accepted.

The fact that equipment for power plants and industrial works is taking the lead in the resumption of business is well brought out by a list of recent sales comprising 80 fans, blowers and exhausters issued by the Green Fuel Economizer Company, of Matteawan, N. Y. These fans are to be used for such purposes as mechanical draft, heating and ventilating, hot-blast drying, etc., and their number indicates that many mills and other plants are being put into shape in anticipation of manufacturing operations on a large scale.

Henry W. Hess, chemist of the Toledo Gas, Light and Coke Company, Toledo, Ohio, made an examination of the liquid removed from a boiler by a Buckeye boiler skimmer and reports that he found the suspended solid to have been composed of calcium and magnesium carbonates mixed with a small amount of clay. In this particular case, the skimmer removed one hundred gallons of such liquid containing solids to the amount of 0.9259 pound per gallon, or 92.59 pounds per hundred gallons, each day. This skimmer is made by the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio.

The Dearborn Drug and Chemical works reports that the general business of the company for the last six months of 1908 was larger than for any other six months in its history, indicating the quick return of prosperous business conditions. The percentage of increase the past few months, and especially for January, in the Eastern department of the company is particularly gratifying. Grant W. Spear, vice-president and Eastern manager, at the general Eastern offices, 299 Broadway, New York, who has been for years vice-president of the Dearborn company, at Chicago, ably assisted by Herbert E. Stone, as general sales manager, P. H. Hogan, manager of the Boston office, and Paul T. Payne, manager of the Philadelphia office, with P. G. Jones as special representative in the Philadelphia district, together with such popular and able representatives out of the New York office as Messrs. McConnaughty, Mitchell and others, constitute a most effective organization, wh'ch is an assurance of the high-grade manner in which the affairs of the Dearborn company will be handled in the Atlantic coast States.

An announcement of interest in the fan and blower business has just been given out—the consolidation of the American Blower Company, of Detroit, and the Sirocco Engineering Company, of New York. S. C. Davidson, of the parent Sirocco works, Belfast, Ireland, is financially interested in the deal. The factory of the Sirocco Engineering Company, at Troy, N. Y., and the plants of the American Blower Company, at Detroit, will continue in full operation under one management, and the home office will be at Detroit. In anticipation of a general improvement in business, also the necessity for increased foundry facilities, and the consummation of the "ABC"—Sirocco consolidation, the American Blower Company purchased outright during 1908 the complete foundry and plant formerly operated by the Northwestern Foundry and Supply Company, Detroit. The large triangular-shaped property, owned and occupied by the American Blower Company since about 1881, being entirely covered by buildings by the completion in 1907 and 1908 of a large steel-plate fan shop and office addition, the company recently purchased a large tract of land across the street, upon which it is expected new buildings, covering approximately 175x300 feet, will be erected. All business of the Consolidated companies will hereafter be transacted under the style and name of American Blower Company. The personnel of the management of the new company is as follows: James Inglis, president, who has been at the head of the American Blower Company; William C. Redfield, vice-president, who was president of the Sirocco Engineering Company; Charles H. Gifford, treasurer, who was, until a year ago, manager of the B. F. Sturtevant Company; Mr. Still, the secretary, is well known, especially among engineers, as chief engineer of the American Blower Company.

New Equipment

The Ozone Ice Company, Bogalusa, La., has awarded contract for the erection of ice plant.

The Athens (Wis.) Electric Light and Power Company contemplates installing larger generators.

The Idaho Power and Transportation Co., Idaho Falls, Idaho, is planning to double its output.

The Lebanon (Ky.) Light, Ice and Power Company is contemplating increasing output of plant.

Water-works at a cost of $20,000 will be constructed at Swink, Colo. E. G. Ritchie, city clerk.

It is reported that the Osceola (Ia.) Light, Heat and Power Company is planning to install an ice plant.

It is reported that water-works will be erected at Kearney, Neb., at a cost of $100,000. G. E. Ford, city clerk.

The citizens of Albion, Neb., voted to issue bonds for the construction of a municipal lighting and heating system.

The Chicago & Northwestern Railroad Company has commenced construction of power house at Clinton, Iowa.

The Jefferson (Texas) Ice, Light and Power Company is contemplating the installation of a producer gas plant.

It is reported that the Blackwell (Okla.) Electric Light and Power Company contemplates installing gas engines in plant.

The Keokuk (Iowa) Gas and Electric Company has been incorporated by Frederick Sargent and associates. Capital, $300,000.

The citizens of Sapulpa, Okla., voted to issue $65,000 bonds for extending and improving water-works. S. N. Hurd, city clerk.

The City Council, Hugo, Okla., will receive bids until February 2 for construction of water-works plant. W. T. Echols, city clerk.

The Sorento (Ill.) Electric Light Company will enlarge its plant. Will need a 150-horsepower engine and 100-kilowatt generator.

The Fowler (Ind.) Utilities Company contemplates installing new equipment, including engine and generator, meters, transformers, etc.

The Citizens Electric Company, Williamsport, Penn., contemplates installing additional equipment, including engines, generators and boilers.

The Union Central Light and Ice Company, Hubbard City, Texas, contemplates the erection of a new electric light plant and an addition to ice plant.

It is said about $40,000 will be expended for reconstruction of municipal electric-light plant at Topeka, Kan. H. K. Goodrich, superintendent.

The Savannah (Ga.) Ice and Storage Company has been organized to establish ice and cold-storage plant. J. G. Nelson, and others, organizers.

The village of Bergen, N. Y., has been authorized by the Public Service Commission to construct a municipal electric-light plant and water-works system.

The Scholl Engineering Company, Youngstown, Ohio, has been awarded contract for constructing water works at Girard, Ohio, and will receive all sub-bids.

Plans are being made to increase the output of the municipal electric light plant, Bethany, Mo. A new generator will be installed. J. F. Slinger, superintendent.

Plans are being considered for the installation of a 500-kilowatt steam turbine in the municipal electric light plant at Jamestown, N. Y. Chas. G. Sundquist, manager.

The West Penn Electric Company is said to be planning the erection of another power house at a cost of over $1,000,000. L. H. Conklin Connellsville, Penn., is general superintendent.

Plans are being considered for improvements at the municipal electric light plant at Elberton, Ga. These will include a new alternator, turbine pump and 50-horsepower motor. G. W. Hubbard, superintendent.

The Pasadena Rapid Transit Company has been incorporated to build an electric line between Pasadena and Los Angeles. Capital, $3,000,000. Incorporators, E. J. Sheehan, W. H. Smith, E. H. May, of Pasadena, and others.

New Catalogs

Hancock Inspirator Company, 85 Liberty street, New York. Catalog. Valves. Illustrated, 40 pages, 6x9 inches.

Thos. H. Dallett Company, Philadelphia, Penn. Catalog No. 100. Air compressors. Illustrated, 24 pages, 6x9 inches.

The M. W. Kellogg Company, 50 Church street, New York. Catalog. Piping and chimneys. Illustrated, 48 pages, 8½x11 inches.

American Steam Gauge and Valve Manufacturing Company, Boston, Mass. Catalog. Valves, Illustrated, 90 pages, 6x9 inches.

Wm. A. Harris Steam Engine Company, Providence, R. I. Catalog. Harris-Corliss engine. Illustrated, 80 pages, 7x10 inches.

Western Electric Company, 463 West street, New York. Bulletin No. 5370. Steam turbines. Illustrated, 12 pages, 8x10½ inches.

Wagner Electric Manufacturing Company, St. Louis, Mo. Bulletin No. 82. Polyphase motors. Illustrated, 16 pages, 8x10½ inches.

Walch & Wyeth, 87 Lake street, Chicago, Ill. Booklet. Erwood straightway swing gate valve. Illustrated, 16 pages, 6½x7 inches.

Ridgway Dynamo and Engine Company, Ridgway, Penn. Bulletin No. 20. Single-valve side-crank engine. Illustrated, 14 pages, 8x10½ inches.

Lathrop Engineering Company, 126 Liberty street, New York. Pamphlet. Lathrop system, of "Equalized Draft" for steam boilers. Illustrated, 16 pages, 4x7½ inches.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

Energy in a Pound of Steam

Net Energy of Expansion from 150 Pounds down to Atmospheric Approximates Energy from Atmospheric down to 27 1-2 Inches of Vacuum

BY FRED R. LOW

A correspondent writes: "In your issue of October 26, page 675, the following statement appears:

> When it is remembered that there is as much power in the steam from atmospheric pressure down to 27½ inches as there is from 150 pounds down to atmospheric pressure, it is easily seen that the power of a non-condensing plant can be doubled by the addition of an exhaust-steam turbine and condenser.—Gerald Stoney, before the British Association.

I would like very much to see this example worked out in full, so that I might follow it step by step."

The energy is proportional to the area of a diagram in which, as in that made by the steam-engine indicator, vertical distances represent pressures and horizontal distances volumes. Fig. 1 is such a diagram, plotted upon the assumption that the product of the pressure and volume remains constant. A volume *o 1* of steam at 120 pounds absolute pressure is expanded to twice that volume *o 2*, and in so expanding generates energy represented by the space *B C 2 1*. It is started with one volume at 120, and since the product of the volume and pressure remains constant the pressure at two volumes *C* must be 60. Notice that this area is made up of a triangle *A B C* and a rectangle *A C 2 1*, each 60 pounds high and one volume wide.

Suppose this steam at 60 pounds to be again doubled in volume. Its pressure would be reduced to 30 pounds and an amount of energy proportional to the area *C D 4 2* would be developed. This area consists of a triangle *C D E*, and a rectangle *E D 4 2*, each 30 pounds high and two volumes wide, and since the area *1 B C 2* is twice as high, but only half as wide as *2 C D 4*, their areas must be equal; and since the work performed is represented by the area the work is the same. If the diagram is followed along it will be seen that the successive areas into which it is divided are equal, and that the last expansion from 15 to 7½ pounds results in the development of as much energy as that from 120 to 60. The energy developed depends upon the number of times the steam is expanded, i.e., the "ratio of expansion," the final volume divided by the initial volume. The energy is the product of the mean pressure during expansion and the increase in volume. In the early part of the diagram the pressure is high and the volume correspondingly small. In the later part of the diagram the pressure is small, but the volume is correspondingly great, and their product (the energy) is equal for the same ratio of expansion.

This much by way of simple illustration, but unfortunately steam does not expand in this way. A perfect gas would expand according to this mode if its temperature were kept constant. Steam cools as it expands and its volume would increase less rapidly than the expansion

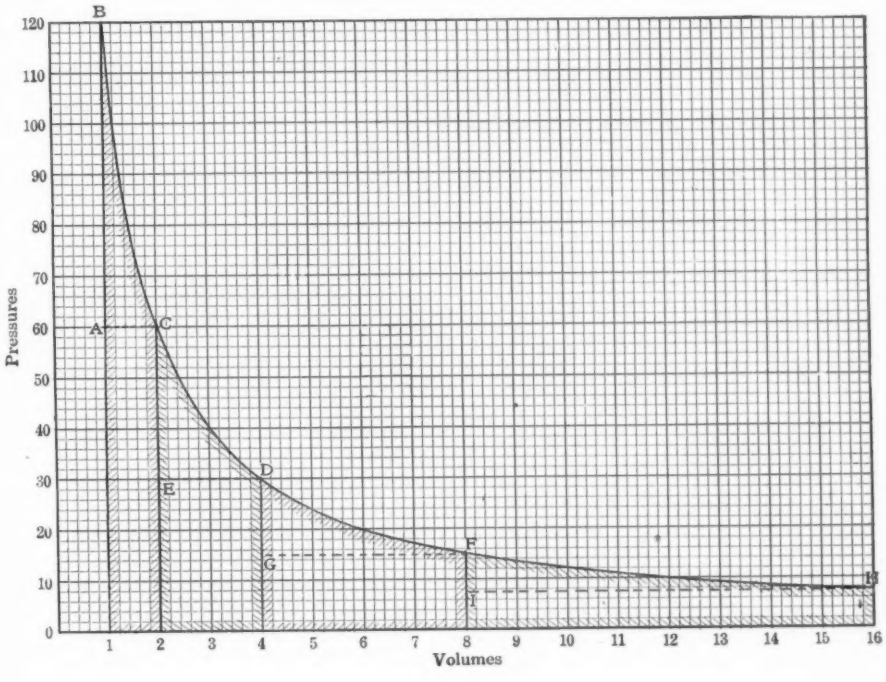


FIG. 1

curve in Fig. 1 shows, dropping the curve. The expansion line of the ordinary indicator diagram follows the line of Fig. 1 quite closely, because there is enough evaporation in the cylinder as the pressure is reduced to make up the shrinkage due to cooling, but this means that the diagram deals with a varying quantity of steam.

Let us go at the problem in another way. Every pound of the working fluid carries into the engine a number of heat units, and in passing out carries away a lesser number. The difference has been converted into work, and if it can be found how many heat units each pound of the fluid carries in and how many it takes out, the difference will be the number of heat units that have been converted into work, for the ideal case at least, for each pound of steam used. As each heat unit is equivalent to 778 foot-pounds the work can be expressed in those units by simple multiplication.

There are reproduced herewith a couple of fragments from Peabody's "Tables of the Properties of Steam." The second line gives the properties for steam of 2 pounds absolute pressure, the pressure *p* being given in the first column. In the second column is given the Fahrenheit temperature at which water will boil under that pressure, in this case 126.3 degrees. In the third column is given the "heat of the liquid" *q*, that is, the number of British thermal units which are required to raise a pound of water from 32 degrees to the above temperature.

Let the line *O X*, in Fig. 2, represent the absolute zero of temperature, 459.5 degrees below the zero of the Fahrenheit scale. On the line *J I* locate, to any convenient scale of vertical distances, representing temperature, the freezing point, 32 degrees, which is the base from which

most of the values of the steam table are reckoned. Locate the point B at the hight corresponding to the temperature, 126.3, to the chosen scale, and at such a distance from the line $I\,J$ that the area $A\,B\,H\,I$ will be proportional to the 94.3 B.t.u., which the table says it has required to bring the water from 32 degrees to this point. In other words, to bring the pound of water from 32 to 126.3 degrees has required 94.3 B.t.u. of energy in the form of heat, and the area $A\,B\,H\,I$ located for different temperatures in this way the change would be found to occur along some such curve as $A\,B\,C$.

At 341 degrees the water under 120 pounds pressure would be ready to boil, and any further addition of heat would go to making it into steam, which process will take place at constant temperature. In the fourth column of the table it will be seen that the "heat of vaporization" r of 120-pound steam is 874 B.t.u., i.e., that

$$874 \times 778 = 679{,}972$$

FRAGMENTS OF PEABODY'S "TABLES OF STEAM PROPERTIES."

1	102.0_{243}	70.0	1043.1	981.1	62.0	0.1332	1.8574	$335.3_{161.3}$	0.00298_{277}	1
2	126.3_{153}	94.3	1026.2	961.9	64.3	0.1756	1.7519	$174.0_{55.4}$	0.00575_{268}	2
3	141.6_{115}	109.6	1015.5	949.6	65.9	0.2012	1.6895	$118.6_{28.0}$	0.00843_{261}	3
4	153.1_{92}	121.1	1007.5	940.6	66.9	0.2201	1.6447	$90.60_{17.22}$	0.01104_{259}	4
5	162.3_{78}	130.3	1001.2	933.4	67.8	0.2351	1.6100	$73.38_{11.56}$	0.01363_{255}	5
6	170.1_{68}	138.1	995.7	927.1	68.6	0.2478	1.5815	$61.82_{8.32}$	0.01618_{251}	6
118	339.8_{6}	310.8	874.8	792.8	82.1	0.4902	1.0946	3.776_{30}	0.2649_{21}	118
119	340.4_{6}	311.4	874.4	794.3	82.1	0.4911	1.0931	3.746_{29}	0.2670_{21}	119
120	341.0_{7}	312.0	874.0	791.8	82.2	0.4919	1.0918	3.717_{28}	0.2691_{20}	120
121	341.7_{6}	312.7	873.5	791.3	82.2	0.4927	1.0903	3.689_{28}	0.2711_{21}	121
122	342.3_{6}	313.3	873.0	790.7	82.3	0.4935	1.0889	3.661_{28}	0.2732_{21}	122
123	342.9_{6}	313.9	872.6	790.2	82.3	0.4943	1.0875	3.633_{28}	0.2753_{21}	123

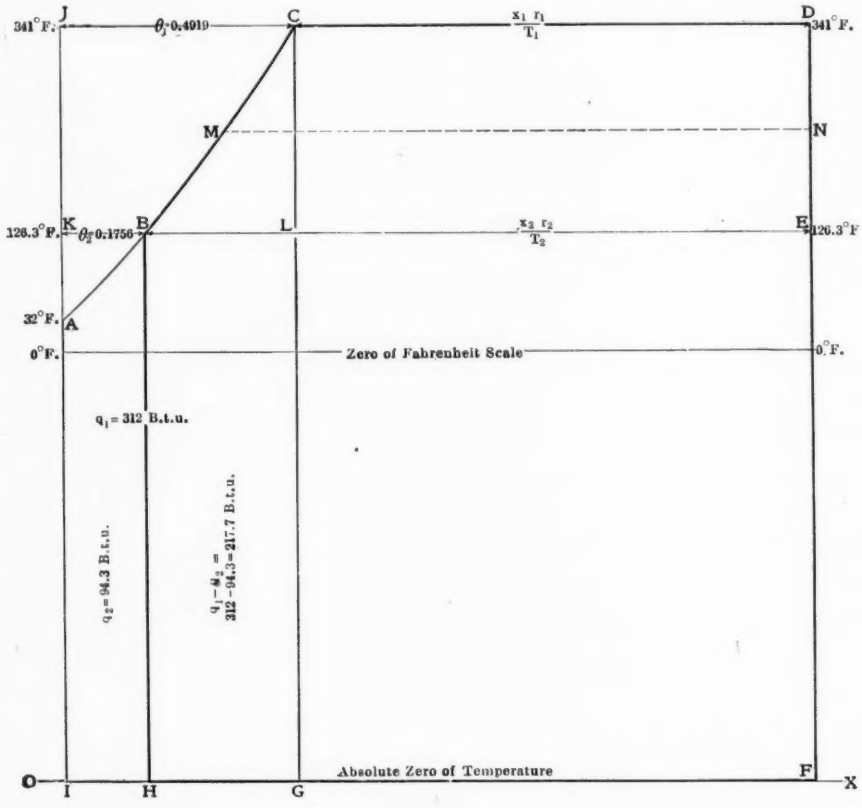


FIG. 2

represents that energy just as the area of the diagram from a steam-engine indicator represents energy.

Now look at the line of the table for 120 pounds pressure. The temperature here is 341 degrees, and the heat of the liquid is 312 B.t.u. Imagine the point C to be located at a vertical distance corresponding to 341 degrees Fahrenheit, and at such a distance horizontally from the line $J\,I$ that the area $A\,C\,G\,I$ will represent 312 B.t.u. If a number of points were located for different temperatures in this way the change would be found to occur along some such curve as $A\,B\,C$.

At 341 degrees the water under 120 pounds pressure would be ready to boil, and any further addition of heat would go to making it into steam, which process will take place at constant temperature. In the fourth column of the table it will be seen that the "heat of vaporization" r of 120-pound steam is 874 B.t.u., i.e., that

$$874 \times 778 = 679{,}972$$

foot-pounds of energy in the form of heat are required to tear the molecules of that pound of water at 341 degrees apart and convert it into dry-saturated steam of the same temperature. Of this energy 822 B.t.u., as shown in the sixth column, are required to push back the surroundings as the water expands into steam, to perform external work $A\,p\,u$, while the rest,

$$874 - 82.2 = 791.8$$

B.t.u., are required to overcome the attraction of the molecules for each other, to do internal work ρ, as shown in the fifth column.

At C the pound of water is about to change into steam. As the process takes place at constant temperature the change of state will be represented by a horizontal line $C\,D$. If the pound of water is all changed to steam the line $C\,D$ must be of such length that the area $C\,D\,F\,G$ will be proportional to 874, the heat of evaporation, on the same scale as the rest of the diagram. If only 0.98 of the water is changed to steam, i.e., if there is 2 per cent. of moisture it will take only

$$0.98 \times 874 = 856.52$$

B.t.u. to make the change, and the area $C\,D\,F\,G$ would be drawn to represent that number of units. Similarly, to produce a mixture of steam and water of any quality x (the quality being the fraction of the mixture which is steam, 0.98 in the above case), will require $x\,r$ heat units, r being the heat that would be required to evaporate the whole pound.

To convert the pound of water from 126.3 degrees, at B, into the pound of steam at 120 pounds, or 341 degrees, has taken an amount of energy in the form of heat proportional to the area of the diagram $B\,C\,D\,F\,H$, made up of $B\,C\,G\,H$, which is the difference between the heats of the liquids q at 341 and 126.3 degrees, and $C\,D\,F\,G$, the heat of vaporization of the mixture and equal to $x\,r$, or to r if x is unity and the steam is dry saturated. Therefore, the heat put into the pound of steam is

$$q_1 - q_2 + x_1\,r_1,$$

the subscripts, or little figures below the letters, meaning at the higher temperature for 1 and at the lower for 2.

Now, suppose expansion to take place without any heat being either added to or taken from the mixture. In Fig. 2 addition of heat has resulted in movement to the right; abstraction of heat would be represented by movement to the left. As the steam expands its temperature falls, and as no heat is added or abstracted the change of state would be represented by a vertical line, as for instance $D\,E$, if the expansion occurred between 341 and 126.3 degrees. This would result in a pound of mixed steam and water at 126.3 degrees, for even if the steam were initially dry-saturated, there has been condensation due to the conversion of heat into work. The area $B\,E\,F\,H$, therefore, represents the heat of vaporization of that part of the pound of working fluid which is still steam, or $x_2\,r_2$. The heat of vaporization r_2 at 2 pounds or 126.3 degrees may be taken from the table. How shall x_2, the quality after expansion, be found?

The area $C\,D\,F\,G$ is proportional to $x_1\,r_1$. Its hight $C\,G = T_1$, the absolute temperature at 120 pounds. Then its

length $C\,D$ must be its area divided by its hight or

$$\frac{x_1\,r_1}{T_1}.$$

The horizontal distance of any point from the line $J\,C$, which passes through the point of 32 degrees, is proportional to the "entropy of the liquid" θ, at the temperature corresponding to the vertical position of the given point. For example, the distance $J\,C$ of the point C is 0.4919, the entropy of the liquid θ, at 341 degrees (see seventh column of the table opposite 120 pounds).

The line $J\,D = C\,D + J\,C$ is proportional, therefore, to

$$\frac{x_1\,r_1}{T_1} + \theta_1.$$

Similarly the line $K\,E$ is proportional to

$$\frac{x_2\,r_2}{T_2} + \theta_2.$$

And since these lines are equal,

$$\frac{x_1\,r_1}{T_1} + \theta_2 = \frac{x_2\,r_2}{T_2} + \theta_2. \quad (1)$$

All of these quantities with the exception of x are obtainable from the steam tables, and if one of the x's is known the other can be easily determined.

The heat remaining after expansion is $x_2\,r_2$.

Then the number of heat units converted into work is

$$x_1\,r_1 + q_1 - q_2 - x_2\,r_2. \quad (3)$$

And if each heat unit is equivalent to 778 foot-pounds, the net energy E_n developed by making a pound of water into steam and expanding it (the energy represented by a pressure-volume diagram like Fig. 3) would be

$$E_n = 778\ (x_1\,r_1 + q_1 - q_2 - x_2\,r_2). \quad (4)$$

For dry-saturated steam expanded from 120 to 2 pounds absolute these quantities become:

$x_1 = 1.$	$x_2 = 0.8038.$
$r_1 = 874.$	$r_2 = 1015.5.$
$q_1 = 312.$	$q_2 = 94.3.$
$p_1 = 7918.$	$p_2 = 961.9.$

and

$E_n = 778\ (1 \times 874 + 312 - 94.3 - 0.8038 \times 1015.5) =$ 214,293 *foot-pounds.*

The area $b\,e\,f\,a$ of Fig. 3 is the product of the pressure and volume of the steam (or mixture) at the lower temperature. It is proportional to the external work done by a pound of water in changing to this mixture. If the working fluid were all steam, this value reduced to B.t.u. would be the $A\,p\,u$ of the sixth column of the table. For x per cent. of a pound still in the condition of steam it would be $x_2\,A\,p\,u$. And this is the amount of work which would have to be done upon the steam to expel it against the 2 pounds back pressure. It would have to be subtracted from the total energy represented by Fig. 4 to get the net energy represented by Fig. 3, but this has been done in formula (4), and in this way. The heat of evaporation r is the sum of the internal energy ρ and this external energy, and when $x_2 r_2$ was subtracted in formula (4) it included this external energy at the lower pressure. Of the 1015.5 B.t.u. making up the heat of evaporation at the lower pressure, 64.3 would be used in pushing back the surroundings, in making room for the steam, in helping to push the piston away, if the expansion takes place in a cylinder, or to accelerate the mass if in a nozzle, so that they are a part of the energy available by the expansion, and should not be subtracted unless it is desired to take out the equivalent work of overcoming the back pressure in expelling the steam.

If the total energy represented by diagram, Fig. 4, were desired, it could be found by subtracting $x_1\,\rho_1$ instead of $x_2\,r_2$ in formula (4), ρ being the heat equivalent of the internal work and the difference between r and the external work, so that subtracting ρ_2 instead of r_2 leaves in the result the external work at the lower pressure, the area $b\,e\,f\,a$, of Fig. 3. The formula for this case becomes:

$$E_t = 778\ (x_1\,r_1 + q_1 - q_2 - x_1\,\rho_2). \quad (5)$$

$778\ (874 + 312 - 94.3 - 0.8038 \times 961.9) =$ 247,812 *foot-pounds.*

If the total energy of expansion, Fig. 5, is desired, the area $a\,b\,c\,d$ of that figure must be subtracted from Fig. 4. This is the external work of the steam at the higher pressure. To push a pound of steam into the cylinder of an engine and make the line $a\,b$, Fig. 3, on an indicator diagram, a pound of water would have to be evaporated in the boiler and the work done by that water in changing into steam is proportional to the area $a\,b\,c\,d$. This can be subtracted by changing the r_1 of formula to ρ_1, because ρ_1 is just this much less than r_1 and this makes the formula for the total energy developed during expansion:

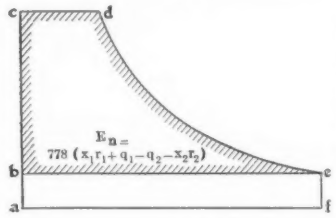


FIG. 3

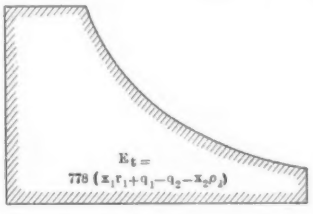


FIG. 4

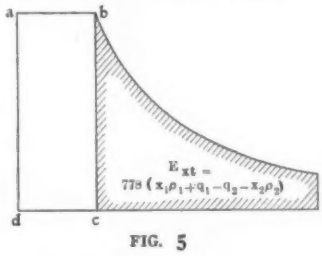


FIG. 5

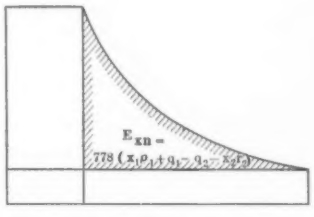


FIG. 6

Transposing formula (1):

$$x_2 = \frac{x_1\,\frac{r_1}{T_1} + \theta_1 - \theta_2}{\frac{r_2}{T_2}}. \quad (2)$$

The values of $\frac{r}{T}$ are given in the eighth column of the table. If you try to calculate them, remember that T is the absolute temperature, i.e., the Fahrenheit temperature plus 459.5.

Assuming dry-saturated steam to start with, $x_1 = 1$, and the following quantities may be found in the table:

$$\frac{r_1}{T_1} = 1.0918. \qquad \frac{r_2}{T_2} = 1.7519.$$

$$\theta_1 = 0.4919. \qquad \theta_2 = 0.1756.$$

Substituting these values in formula (2):

$$x_2 = \frac{1 \times 1.0918 + 0.4919 - 0.1756}{1.7519}.$$

This is only common arithmetic:

1.0918
1 Multiply.
1.0918
0.4919 Add.
1.5837
0.1756 Subtract.
1.7519) 1.4081 Divide.
0.8038 = x_2.

The heat put into the pound of steam was

$$B\,C\,D\,F\,H = x_1\,r_1 + q_1 - q_2.$$

$$E_{xt} = 778\ (x_1\,\rho_1 + q_1 - q_2 - x_2\,\rho_2). \quad (6)$$

$778\ (791.8 + 312 - 94.3 - 0.8038 \times 961.9) =$ 183,861 *foot-pounds.*

And, finally, to get the net energy due to expansion, that represented by Fig. 6, the energy to expel the expanded steam must be deducted, which can be done by adding it to the amount to be subtracted in formula (6) by changing the ρ_2 to r_2:

$$E_{xn} = 778\ (x_1\,\rho_1 + q_1 - q_2 - x_2\,r_2). \quad (7)$$

$778\ (791.8 + 312 - 94.3 - 0.8038 \times 874) =$ 150,342 *foot-pounds.*

Applying these formulas to the case quoted by our correspondent the results would be as follows, showing that it was the net energy of expansion which Mr. Stoney had in mind in making the statement quoted:

	From 150 lb. Absolute to Atmospheric.	From Atmospheric to 27½ in. vacuum.
Total energy of generat'n and expansion (Fig. 4)..	180,503	165,877
Net energy of generation and expansion (Fig. 3)..	131,391	123,110
Total energy of expansion (Fig. 5).....	115,695	109,550
Net energy of expansion (Fig. 6)	66,583	66,783

Herewith are shown parts of two pages

from Peabody's Temperature-Entropy Table. On the first follow the line for 358 degrees (the temperature in even degrees most nearly corresponding with 150 pounds) to the quality nearest unity, which will be in the triple column on one side or the other of the broken line extending zigzag across the table. To the right of that line the figures in the column marked quality mean degrees of superheat, while to the left they mean the fraction of the pound converted into steam, the x of the foregoing calculations. The quality nearest unity lies in the triple column under No. 1.56, and gives the heat contents as 1185.

On the other page in the column bearing the same number, 1.56, and opposite 212, find the heat contents (after expansion to that temperature) of a pound of steam (having the initial quality given at the higher temperature) to be 1018.

Temperature, Degrees Fahr.	Pressure, Pounds per Square Inch.	1.56			1.57		
		Quality.	Heat Contents.	Specific Volume.	Quality.	Heat Contents.	Specific Volume.
372	177.9	7	1200	2 596	21	1208	2 654
371	175.7	5	1198	2 620	19	1207	2.680
370	173 6	4	1197	2 646	18	1206	2 706
369	171 .5	3	1196	2.672	17	1205	2.732
368	169 .4	2	1195	2.700	16	1204	2.760
367	167 .3	1	1194	2.725	14	1203	2 786
366	165 .3	9997	1193 .3	2.752	13	1202	2.814
365	163 .2	9988	1192 3	2 782	12	1201	2.842
364	161 .2	9979	1191 2	2 812	11	1200	2 870
363	159 .2	9971	1190 .2	2.843	10	1199	2.899
362	157 .2	9963	1189 .2	2 874	8	1198	2 928
361	155 .3	9955	1188 1	2 906	7	1197	2.957
360	153 .3	9946	1187 .1	2.938	6	1196	2.986
359	151 .4	9938	1186 .1	2.971	5	1195	3.017
358	149 .5	9929	1185 0	3 004	3	1193	3 047
357	147 .6	9921	1183 .9	3 .037	2	1192	3 .079
356	145 .8	9913	1182 .9	3 .070	1	1191	3 .108
355	143 .9	9904	1181 9	3 105	9998	1190 0	3 135
354	142 .1	9895	1180 .8	3 141	9989	1189 .0	3 170
353	140 .3	9887	1179 .8	3 .176	9980	1187 .9	3 206
352	138 .5	9878	1178 .7	3 .211	9971	1186 .8	3 .242

Temperature, Degrees Fahr.	Pressure, Pounds per Square Inch.	1.56			1.57		
		Quality.	Heat Contents.	Specific Volume.	Quality	Heat Contents	Specific Volume.
228	20.02	8809	1037.7	17.56	8881	1044.6	17.70
227	19.64	8800	1036.5	17.86	8872	1043.4	18.00
226	19.28	8791	1035.3	18.17	8863	1042.2	18.32
225	18.91	8782	1034.1	18.48	8854	1041.0	18.63
224	18.56	8774	1032.8	18.79	8845	1039.7	18.95
223	18.21	8765	1031.6	19.12	8836	1038.5	19.27
222	17.86	8757	1030.4	19.44	8828	1037.2	19.60
221	17.52	8749	1029.2	19.78	8820	1036.0	19.94
220	17.19	8740	1028.0	20.13	8811	1034.8	20.29
219	16.86	8731	1026.7	20.48	8802	1033.5	20.65
218	16.53	8721	1025.4	20.84	8792	1032.2	21.01
217	16.21	8713	1024 2	21.21	8783	1031.0	21.38
216	15.90	8704	1022.9	21.58	8774	1029.7	21.75
215	15.59	8695	1021.7	21.96	8765	1028.5	22.13
214	15.29	8687	1020.5	22.35	8756	1027.2	22.53
213	14.99	8678	1019.3	22.74	8748	1026.0	22.93
212	14.70	8669	1018.0	23.11	8739	1024.7	23.30
211	14.41	8660	1016.8	23.48	8730	1023.5	23.67
210	14.12	8652	1015.5	23.90	8721	1022.2	24.10
209	13.84	8643	1014.2	24.34	8712	1020.9	24.53
208	13.57	8634	1013.0	24.78	8703	1019.7	24.98

SECTIONS OF PAGES FROM PEABODY'S TEMPERATURE-ENTROPY TABLES

If the difference between the heat contents at the two conditions be multiplied by 778 to reduce it to foot-pounds, it will be found that

$$778\ (1185 - 1018) = 129{,}926$$
foot-pounds,

which is the total net energy, Fig. 3, for one pound of steam in that initial condition expanded adiabatically through that range.

Under the same column (1.56) and opposite 108 the heat contents are given as 879.7, so that if this same pound of partially condensed steam is further expanded down to 108 degrees the energy developed will be

$$778\ (1018 - 879.7) = 107{,}597$$
foot-pounds.

But starting over again with practically dry steam at atmospheric pressure the table says that steam at 212 degrees and 99.89 per cent. dry has a heat content of 1145.6 B.t.u. This same steam expanded to 108 degrees would have 987.5 B.t.u. (found by locating the value for the lower temperature in the same column of entropy) and

$$778\ (1145.6 - 987.5) = 123{,}000$$
foot-pounds.

Numerous diagrams have been devised from which these values can be measured. Of such are those by H. F. Schmidt and W. C. Way, on page 524 of POWER for August, 1907, and one by R. M. Neilson, which will appear soon.

It is the heat which develops (or reappears as) work in falling from one temperature level to another, and it is the temperature range rather than the pressure range which should be compared when the relative amount of work is in question. The temperature of steam of 150 pounds absolute is 358.3 degrees, and of steam at 27½ inches vacuum about 108 degrees, so that the ranges compare as follows:

358.3	212
212.0	108
146.3	104

A glance at Fig. 2 will show that the energy represented by a diagram like Fig. 3 will not be the same for the same range of temperature; $B\,C\,D\,E$ of Fig. 2 is equivalent to $b\,c\,d\,e$ of Fig. 3. The dotted line $M\,N$ divides the temperature range equally, but the energy, equivalent to the area $M\,C\,D\,N$ developed by the fall through the first half of the range, is less than that, equivalent to $B\,M\,N\,E$, developed by the fall through the second half. If the cycle were changed to $C\,D\,E\,L$ it is plain that equal falls in temperature would produce equal amounts of work. Just as the vertical line $D\,E$ represents expansion without reception or loss of heat (adiabatic or isentropic expansion), so the line $L\,C$ represents compression by the same mode. The diagram then consists of a line $C\,D$, representing expansion at constant temperature (the expansion of the water into steam represented by the steam line of the pressure-volume diagram $c\,d$, Fig. 7), a line $D\,E$, Fig. 2, representing adiabatic expansion ($d\,e$ in Fig. 7), a line $E\,L$, representing compression at constant temperature (the line $e\,l$ of Fig. 7, during which the steam is being reduced to its original volume at the constant temperature of the condenser), and the line $L\,C$, representing adiabatic compression to the original temperature ($l\,c$ in Fig. 7). This is called the Carnot cycle, and from steam worked in this way the energy produced and represented by a diagram like Fig. 7 will be directly proportional to the temperature range.

A Dangerous Omission

BY W. H. WAKEMAN

POWER for October 20, 1908, contained a short article under the above title, and the illustration is herewith reproduced for reference with the following explanation (see Fig. 1): A direct-acting steam pump A is used to operate hydraulic elevators. It discharges water through B into the pressure tank C. A relief valve is shown at D, which opens and allows water to flow into the surge tank E when the safe limit of pressure is reached. A power pump F was installed and is driven by an electric motor. It was connected to the system by inserting the cross G. The relief valve D was removed and connected at H, while I represents a stop valve.

The original article called attention to the fact that I might be closed and F started, thus causing trouble and expense by creating a very high water pressure from which there would be no automatic relief.

This is exactly what did happen about midnight a short time ago, since the original article appeared. There was no engineer in charge, but the fireman on duty heard an unusual noise in the pump room. On going in to investigate the matter he found that the heavy cast-iron air chamber that formerly was located at J had leaped upward, making a large dent in the ceiling above it, and had then fallen to the floor, while water was coming out of an irregular hole that was left when the air chamber failed. The switch was pulled out and the pump stopped.

The air chamber is illustrated in Fig. 2. The break occurred in the lower part of

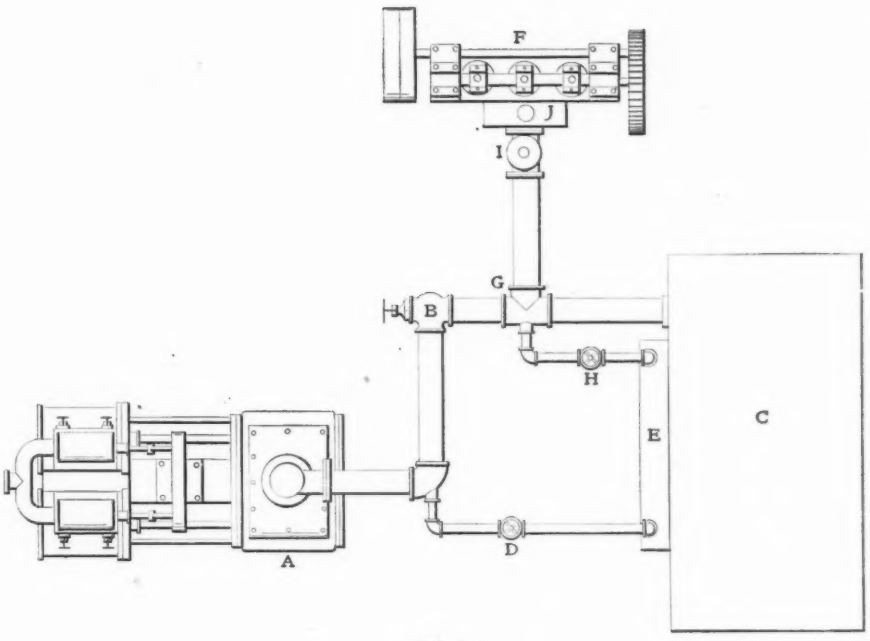


FIG. 1

the neck, which is 5 inches in diameter, while the head above it is 12 inches. It is about 31 inches high above the break, and the flange below is 14 inches. Fig. 3 is a plan of the broken flange, showing a rupture of very irregular form. The iron is from $\frac{7}{32}$ to $\frac{11}{16}$ inch thick; its appearance indicates that the break was new, and the metal was free from air holes, etc.

It is morally certain that the immediate cause of this so-called accident was the fact that the valve *I*, Fig. 1, was closed, and as this prevented the relief valve *H* from opening, a very high pressure accumulated in a short time, especially as it could not find even partial relief by starting seams in the tank *C*, as it did on a former occasion. The automatic electrical apparatus evidently failed to work properly.

Fig. 4 illustrates the pressure gage that is connected to this pump. The pointer evidently made a complete circle on the dial and was forced against the pin with sufficient force to loosen it from its pivot; consequently, it gave up in despair the effort to indicate the great pressure resulting from this mismanagement and hung idly on the pivot, point downward.

The following facts should be taken into consideration in this connection: The power pump *F* was installed a few months ago by two well informed engineers. They advised the superintendent, who has had no previous experience with steam and electrical machinery, to install a relief valve between *I* and *J*, and offered to supply the valve and install it complete for $30, but he replied that it was unnecessary; therefore, it was omitted, with the stated result, which is what would be expected by any practical engineer.

Less than 10 days previous to this failure the night engineer, who held a license the night previous to the date of disaster; under the city government, was kept on duty for 36 hours, because nobody was provided to release him, and then discharged for some trivial fault a few days later. He finished his labors at this plant therefore, it occurred the first night that a new man was operating the machinery. The new man had not secured a license for this plant, as the law allows one week in which to secure the necessary papers. The trouble could not have been caused by the discharged employee, as the day fireman operated the plant for 12 hours after he left, and the night man had been on duty for several hours when the failure occurred. While the night fireman could have kept the valve *I* open while the pump was either in active operation, or else liable to be started automatically at any time, and thus maintain communication with the relief valve *H*, the superintendent, who allowed such a dangerous state of affairs to exist after he had been informed of it and warned of what might happen at any time, is directly responsible. A relief valve, which is only another name for a safety valve, should never be located where an ignorant or careless fireman can prevent it from operating by closing a valve, and any man who does not understand this principle, or is not sufficiently impressed with its importance to apply it rigidly, is not qualified to have charge of a steam plant located in one of the largest buildings in the central part of the city of which it forms a conspicuous part.

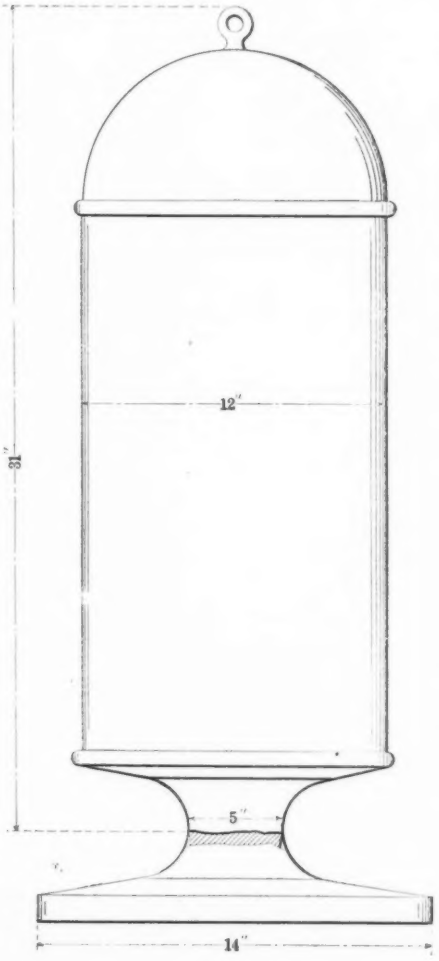


FIG. 2

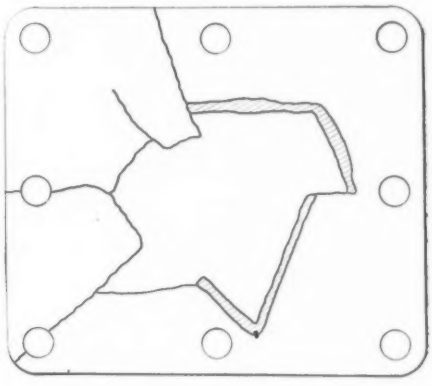


FIG. 3

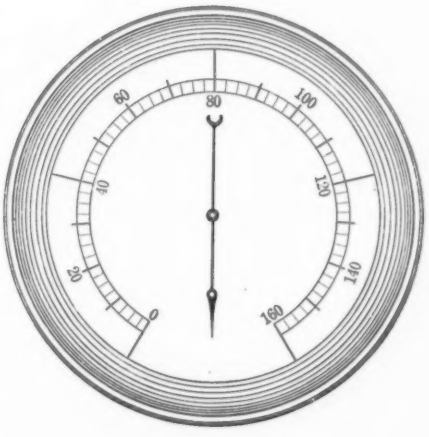


FIG. 4

The Plunger Hydraulic Elevator

Construction and Operation Details of the Highest Type of Passenger Elevator Made by the Standard Plunger Elevator Company

BY WILLIAM BAXTER, JR.

For the highest type of passenger elevator the Standard Plunger Elevator Company uses the system shown diagrammatically in Fig. 302. In this arrangement it will be noticed that the discharge tank *G* is located several floors above the top of the lifting cylinder. The hight of the discharge tank varies according to the car speed, and ranges from about 40 feet for

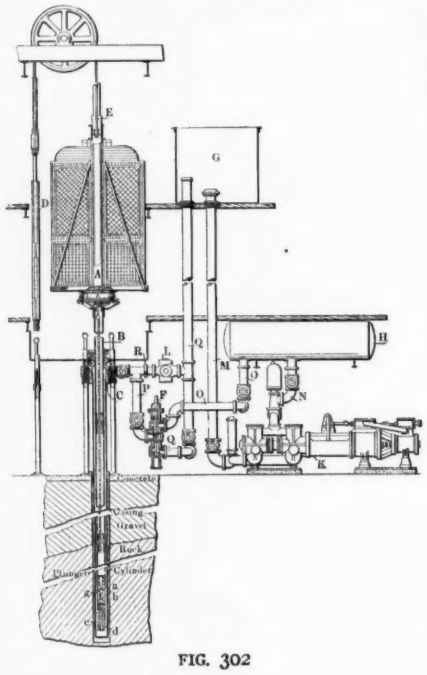


FIG. 302

moderate car speed to double this hight for speeds of 500 or 600 feet per minute. In addition to setting the discharge tank at an elevation, the discharge pipe *Q* is connected with the inlet pipe *P* through a branch *R* in which is inserted a check valve *L*. The object of this pipe connection is twofold; first, it prevents drawing the plunger away from the water in making stops on the upward trips and, second, it saves a considerable quantity of pressure water, and thereby increases the efficiency of the apparatus. The valve *L* permits water to flow freely from the pipe *Q* into the cylinder, but prevents water from passing through it from the cylinder to the pipe *Q*. The operation of the system is as follows: Suppose the elevator is running up at full speed and that the operating valve *F* is closed quickly; then the momentum of the counterbalance *D* will carry the car upward and draw the plunger away from the water, as explained in previous articles. This would be the effect if the pipe connection *R* were not provided, but with this connection, as soon as the plunger begins to draw away from the water, the vacuum developed, assisted by the pressure due to the elevation of the tank *G*, will cause water to run down through the pipe *Q*, the valve *L* and the pipe *R* into the cylinder and keep the latter full. When the plunger comes to a state of rest there is no empty space under it, and as a result the car will not drop down as would be the case if water could not enter the cylinder.

To avoid drawing the plunger away from the water by too rapid a valve closure on the upward trips when the simple pipe arrangement of Fig. 301 is used, the pilot valve is adjusted so that the main valve cannot close too rapidly. With the arrangement of Fig. 302 it is immaterial how quickly the main valve is closed, providing the discharge tank is placed high enough to develop as much pressure as may be necessary to cause water to flow in through the pipe *R* and follow up the plunger as fast as it moves until its motion is arrested by the greater weight of the car. All the water that is drawn into the cylinder through the pipe *R* in making stops represents energy saved, because it reduces the amount of water drawn from the pressure tank *H*.

It is not practicable in all buildings to set a discharge tank at the desired elevation, and in such cases the elevated tank *G* must be replaced by a pressure tank located in the basement. A system of

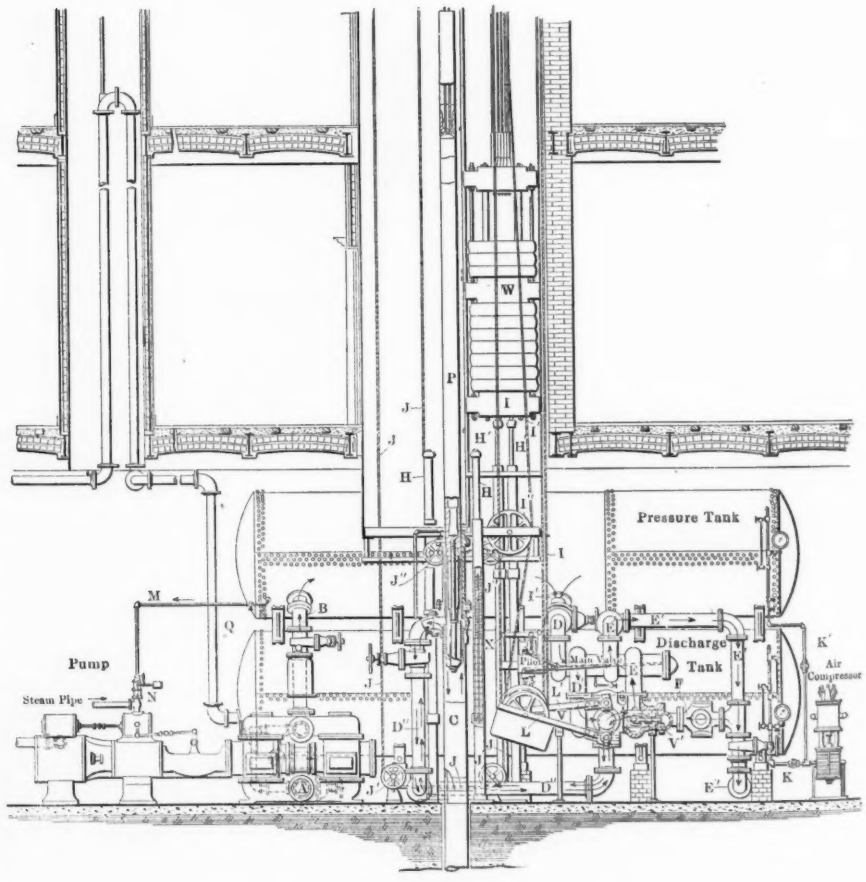


FIG. 303

this kind is shown by Fig. 303, which is far more elaborate than Fig. 302 and shows every detail of a high-class passenger-elevator system. Of the two tanks shown, the top one is the pressure and the lower one the discharge tank. The pipe *Q* leads to an inverted U consisting of two legs, as shown, the function of

which is to maintain a uniform pressure in the discharge tank. This U-pipe is extended up to whatever hight may be necessary to develop the required pressure. At the bend at the top a short vent pipe is provided, which is open at the upper end, so as to prevent the inverted U from acting as a siphon and drawing the water out of the tank. The pilot-valve lever *X* is actuated by the rope *J* which runs under stationary sheaves *J'* at the bottom and over and under the two sheaves *J"* at the top of the pit at the bottom of the shaft. At the top of the building the rope *J* runs over other sheaves, as shown in Fig. 304 which represents all the apparatus at the upper end of the elevator well, and also the elevator car. The lever *L* of the top automatic stop valve *V* is actuated by the rope *I*, and the lever *L'* of the down automatic stop valve *V'* is actuated by the rope *I'*. The points of attachment of these ropes to the car and the way in which they are supported at the top of the elevator well are shown in Fig. 304.

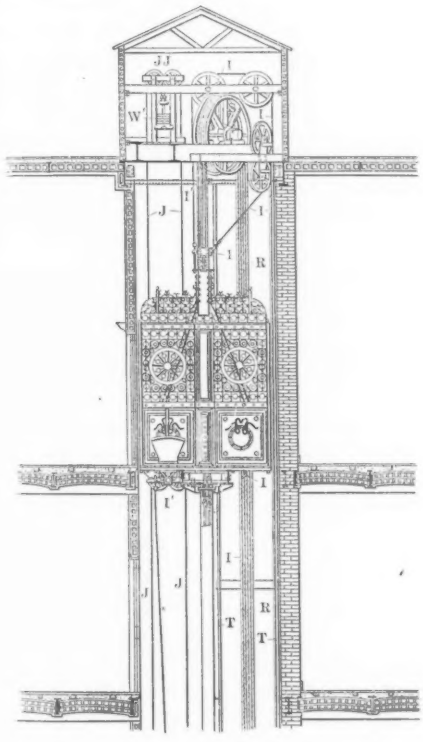


FIG. 304

The construction of the car buffers is shown in Fig. 303 at *H H*. The counterbalance buffers are of similar design, but are not generally provided with the rubber cushions shown below the spiral springs in the car buffers. If either the car or the counterbalance strikes the buffers running at a high speed, the latter are pushed down until the compression of the springs arrests the motion. The stroke of the buffers depends on the speed of the elevator, being made greater as the speed increases. The pump on the right draws water from the discharge tank through the suction pipe *A*, and delivers into the pressure tank through the pipe *B*. The air compressor forces water into the discharge tank through the pipe *K* and into the pressure tank through pipe *K'*. Each tank is provided with gages to show the pressure and the water level. The compressor is run only occasionally, when the air supply runs low. The operation of the main pump is controlled by a pressure regulator *N* which is connected with the pressure tank by the pipe *M*. This regulator controls the valve in the steam pipe and thus stops and starts the pump whenever required by the variations of pressure in the tank.

The operation of the elevator is as follows: To start on the up trip the pilot-valve lever *X* is depressed, causing the main valve to be moved to the left; this allows water to pass out of the pressure tank through the pipe *D* and the main valve to the connection *D'*, thence through the top stop valve *V'* to the pipe *D"*, and to the cylinder *C*, forcing the plunger *P* and the car upward. If the car is stopped on the up trip, the flow of water through this path is arrested by the closing of the main valve, and if the latter closes so rapidly that the plunger starts to rise above the water in the cylinder, then the water in the lower discharge tank flows upward through the pipe *E"*, to and through the check valve *F* and into the chamber of the down stop valve *V'*, as indicated by the dotted lines back of the valve; from here it runs into the cylinder until the car stops. In this drawing the check valve *F* is the same as the valve *L* of Fig. 302. When the car is running upward the valve *V'* is open so that water coming from the discharge tank through the check valve *F* can pass through it freely. When the car is descending also the down stop valve *V'* is open until the lower floor is reached; consequently, the discharge water returning from the cylinder *C* can pass from the pipe *D"* to the connection *E*, thence through the main valve to the pipe *E'* and to the discharge tank through the pipe *E"*.

The automatic stop valves shown in Fig. 303 are arranged slightly different from those presented in Fig. 283, this arrangement being in the position of the shafts upon which the operating levers are mounted. The main valve also is provided with a safety feature not shown on other drawings. These points of difference can be understood by inspection of Fig. 305, which is an enlarged sectional view of the main and stop valves of Fig. 303. The advantage of placing the shafts *B* and *A* one above the other is that the levers *W* and *V* can be attached directly to them, while in the construction shown by Fig. 283 one of the levers swings on the shaft of the opposite lever, and imparts movement to its own shaft through spur-gear segments. In Fig. 305 the operation of the stop valves does not appear to be practicable because it looks as if a very small movement of the crank *V"* to the left would carry it into the crank *W"*. This difficulty can be fully cleared up by the aid of Fig. 305, which is a vertical section at right angles to the view in Fig. 306 and passing through the centers of the shafts *A* and *B*. Looking at this drawing it will be seen that the cranks

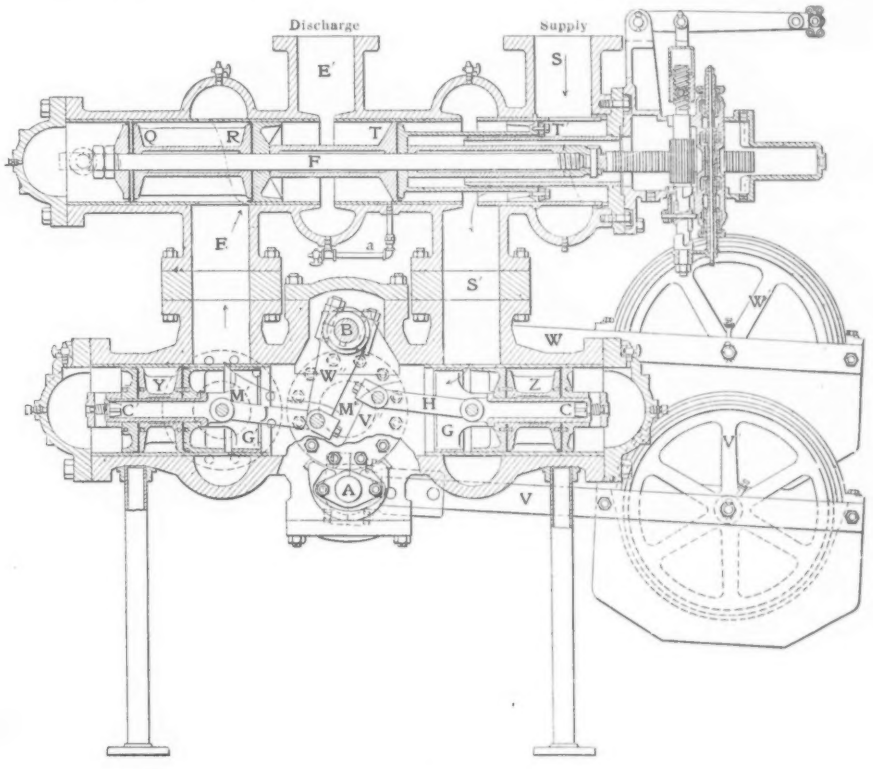


FIG. 305

V'' and W'' are made so that they can swing past each other. This view also shows the way in which the bearings of the shafts A and B are made water-tight by the use of the cup packings a' and b'. The shafts are incased in brass tubing $a\,b$ to prevent corrosion.

The safety device attached to the main valve in Fig. 303 is clearly shown in Fig. 305; it consists of the small pipe connection a, and its operation is as follows: Suppose the car is running upward; when it reaches the upper floor the top stop valve Z will close, and at the same time the main valve piston T' will move to the left, thereby locking pressure water in the space S' between the main valve and the stop valve. This pressure will force the cup packings of the stop valve Z out so as to develop possibly sufficient friction to prevent the lever V and the weight of the sheave V' from shifting the valve to the open position when the car starts on the down trip. When the pipe a is

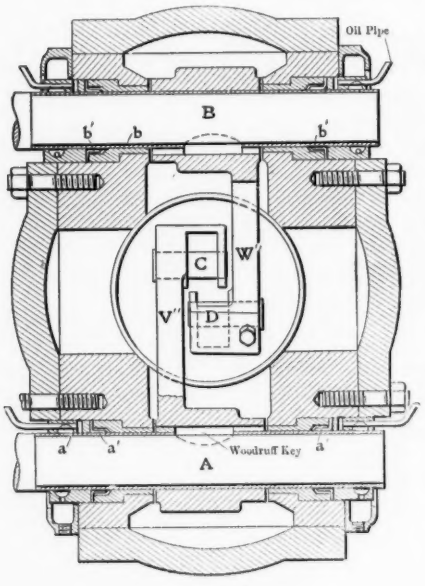


FIG. 306

provided this cannot happen because in order to run the car down the main valve has to be moved to the left so that the piston R may be carried beyond the port and thus open communication between E and E'. As soon as the main valve moves far enough for the piston T to pass to the left of the inlet of the pipe a, the pressure in S' drops to equality with that in E' and then the friction of the cup packings of the valve Z is so reduced that the valve cannot stick. It might be said that this same result could be accomplished by putting additional weight on the lever V, but this would increase the tension on the operating rope, which is objectionable.

Professor Rateau has granted a license to the British Westinghouse Company for the manufacture of his steam turbine and the company has sold two units of 5000 kilowatts capacity each to London city.

Coal Specifications and Tests

By A. V. Doane

The practice of buying coal by specification, rather than by trade name or other time-honored methods, is rapidly increasing among large purchasers of fuel, and while this tendency is undoubtedly in the right direction, it is by no means a simple matter to write satisfactory specifications or properly to enforce them when written.

It is practically impossible to draw any general specification which shall be universally applicable, for the reason that coal is a natural product varying widely in composition from lignite to graphite. The great variety of purposes for which coal is used and the conditions under which it is burned make it necessary to select the kind best suited to the particular work to be done, if the best results are to be obtained. The most that could be done in the way of general specifications would be to formulate requirements suited to the different classes of service.

As by far the greater part of the bituminous coal mined is used for generating steam, specifications for coal to be used for this purpose have naturally been given the most attention. Even in this special use of fuel there are wide variations, as the quality and composition of the coal which can be economically obtained in different sections of the country vary considerably.

The types of boiler and furnace in use should be considered in specifying the quality of coal desired. For instance, vertical boilers do not give as good results with coal containing a high percentage of volatile matter as the horizontal type, while even a gas coal can be burned smokelessly and efficiently in a properly designed and proportioned furnace.

If more care were given to selecting the coal best suited to the particular case under consideration, and to the training and supervision of firemen, the smoke nuisance would be largely abated, with considerable saving in the fuel charges.

There is generally, at first, considerable opposition on the part of coal dealers to bidding according to specifications. There are several reasons for this: The opportunity for selling inferior coal at a good price is much diminished; there are more bother and detail about delivering and billing; also, a quite general fear that, owing to rejections or onerous requirements, they will sustain losses, which fear often leads to an increase in the price bid as a precautionary measure.

Ill-advised and too severe specifications or lack of judgment and tact in enforcement have sometimes caused a prejudice against this method of purchasing coal, also, but as a rule, if the dealer is treated fairly and the matter is properly explained, he soon becomes accustomed to the change. The honest dealer is protected by the specification method, as unscrupulous competitors who under the old system might have bid on furnishing some well known high-grade coal, intending to substitute an inferior and cheaper grade when making deliveries, will hesitate about playing this trick if they know that the coal will be tested and that they will be held strictly to the terms of the contract.

Writing Specifications

In writing specifications the properties which the coal should possess must be carefully considered, having in view the types of boiler, furnace, stoker, etc., methods of handling, storage and disposal of ashes, character of the load on the engines and the characteristics of the coals which can be readily obtained in the locality.

The amount required, place and time of delivery, mechanical condition of the coal and allowable proportion of slack should be specified. The maximum percentage, based on dry coal, of ash, volatile matter and sulphur and the minimum of B.t.u. per pound should be defined. Also, the coal should not heat dangerously when stored in large piles, nor cause an undue amount of smoke when fired with reasonable care.

In some cases the bidder is allowed to submit his own specifications covering the properties which he guarantees the coal shall possess, and the payment is based on the success of the contractor in delivering coal up to the standard he has set. If the price paid is based on the B.t.u. contained and the coal is weighed when received, the determination of the heating effect may be based on the coal as received, thus correcting for moisture.

The methods of sampling and testing should be described and in case of disagreement between the contractor and purchaser some way should be provided, generally by calling in a disinterested expert, of settling the controversy.

The basis of payment is, of course, one of the most important features of the contract. It is usual to pay the price per ton quoted by the successful bidder, deducting a specified amount as penalty for failure to deliver coal up to the standard, and adding a stated sum as premium for exceeding the requirements. The amount of B.t.u. per pound and the percentage of ash are generally the items on which premiums are paid or penalties deducted, but in some cases the amounts of volatile matter and moisture are included. In some instances, too, any variation from the specified standard makes a change in the price.

Another method, and one which, considering the unavoidable errors in sampling and testing, seems more equitable, is to allow a small variation, perhaps 1 or 2 per cent., above and below the standard before the premium or penalty becomes operative. The amount to be deducted

or paid as premium should be given careful consideration in order to protect the interests of both parties to the contract. The purpose should be to deduct enough from the price bid to make good any loss sustained by the purchaser through failure to receive coal of the specified quality and to add enough to reward and encourage the contractor if the standard is exceeded.

It may be said that if the required B.t.u. per pound are received it is hardly fair to make a deduction for excess percentage of ash, but aside from payment for inert matter there are other important considerations: In using a coal having a high ash content more coal must be handled by the fireman to produce a given result, the ash must be heated to the temperature of the furnace and much of this heat is lost. The ash clogs the fire, requiring more draft; the fire must be sliced or shaken more frequently, resulting in a loss of unburnt coal through the grates, a greater tendency to form clinkers and increased expense in handling and disposal of ashes. If the ashes have to be carted to a considerable distance, this item alone may make it economical to buy a higher-priced coal with a small percentage of ash, rather than a cheaper coal with high ash content.

In the case of Government, State or municipal contracts, the bidder is usually required to make a deposit with his bid, which may be retained if he fails to execute the contract, if it is awarded to him, and the successful bidder is also required to give bonds to insure the satisfactory carrying out of his obligations.

Tests

It was formerly the custom to calculate the heat units in the coal from the results of an ultimate analysis. This method has been largely superseded by the calorimeter test which is more accurate and can be made rapidly and conveniently, especially if a simple and easily manipulated calorimeter is employed.

In addition to the heat units, determinations of moisture, volatile matter, sulphur and ash are commonly made.

The moisture test is a difficult one to make with accuracy as, if an attempt is made to drive off all the water by heating the coal, some of the combustible volatile is very likely to go with it.

In the same manner the test for volatile matter shows that there is no well-defined line between combined water and combustible volatile matter on the one hand and between the latter and so-called fixed carbon on the other. In order to minimize the error it is customary to heat the coal in a platinum crucible for a definite time over a standard flame.

The test is an important one, as the percentage of volatile matter plays an important part in the heating effect, and while a high volatile coal may give a satisfactory result in the calorimeter, it does not follow that it will make an equally good showing under the boilers, unless the plant is particularly adapted to burn coal of this kind. If anthracite screenings, buckwheat or some of the other small sizes of hard coal are mixed with the bituminous coal the percentage of volatile in the soft coal may be considerably higher than would be desirable if it were to be used alone. It is much more difficult to secure smokeless combustion with a high volatile coal than with one containing only a moderate amount.

It is customary in reports on boiler tests to state the evaporation per pound of combustion or coal free from moisture and ash regarding the residue, after subtracting these constituents as entirely combustible. This assumption has been shown to be erroneous, as in some coals, particularly those from the western part of the country, a large proportion of the supposed combustible volatile is in reality water of composition. This error ranges from 3 or 4 per cent. for Eastern coals to 14 or more for Western, so that if a true basis of comparison is desired an ultimate analysis is required.

The test for sulphur is of considerable importance with some coals, particularly those from the West, which contain from 1 to 5 per cent. While sulphur is combustible, it has only about one-quarter of the calorific value of carbon. It makes a fusible ash, especially when combined with iron or iron pyrites. The melted ash runs into the air spaces, stopping the air supply and often ruining the grate.

The hot gases containing sulphur are commonly supposed to attack iron, but it is doubtful if the comparatively cool boiler shell is injured; but highly heated ironwork in smoke stacks, etc., may be attacked, and if the sulphurous products of combustion combine with moisture, an acid is formed which rapidly corrodes ironwork exposed to its action.

It is popularly supposed that so-called spontaneous combustion of coal is caused by the sulphur present, but investigation has shown that while the oxidation of pyrites in a coal which has a tendency to heat may play some part in starting the action, the true cause is the capacity of the coal to absorb oxygen, which seems to depend on the molecular condition.

Some coals low in sulphur heat dangerously, while others with a high content of this element give no trouble. Great care should be taken to avoid getting a dangerous coal, as a large mass of coal on fire in the storage bins or pile is an expensive and dangerous proposition.

There appears to be no reliable test which will give absolute information about the heating tendency, although coal which retains considerable moisture when air-dried is said to be more likely to heat. Freshly mined coal containing a large proportion of dust is more liable to heat, especially if wet when stored.

In making coal tests one of the most important operations is the collection of the sample, as it is evident that if this is not truly representative of the coal, the care and refinement with which the tests are carried out are of little use.

If the coal is delivered by carts or hoisted in buckets a small quantity may be taken from each load or from the tubs or conveyers at convenient intervals and put in a pile, from which the sample is taken. If necessary to obtain the sample from a pile or car, small portions should be taken from different parts, not only on the surface but at some distance below, as there is a tendency for the heavier lumps, which contain the most slate or bone, to settle to the bottom, particularly in railroad cars.

Enough coal should be taken to make a pile containing about one bushel. This should be spread out flat on a clean, dry surface and all large lumps broken. The pile should then be divided into quarters and a section rejected. The lumps should then be broken finer and the coal shoveled over, thoroughly to mix it, and again quartered and a section rejected, repeating the operation until there remains but a small quantity, containing no lumps larger than a pea, from which the sample for analysis is taken and placed in an air-tight can or jar holding about one quart. A tin can with a friction top, such as is used for paint or varnish, is convenient.

In order to identify the sample a brass label holder, such as is put on drawers or cases, may be bent to fit the outside of the can and soldered at the corners to hold it in place. A card is then slipped into the holder with the necessary information written on it. The card is changed when the can is used again.

The sample should be taken by a representative of the purchaser and little dependence should be put on tests of single lumps or of samples sent in by bidders. It is common practice for dealers to send a carefully selected sample to some well known chemist for analysis and then publish his report to show the high quality of the coal. It is more than probable that a test of a sample of the coal as received by the purchaser will fail to equal the figures given in the report.

In making contracts it is usual to specify that the tests are to be made in accordance with the methods adopted by the American Chemical Society. Experience has shown that if the specifications are so drawn that the purchaser gets the coal which is best suited to his plant and requirements, if the tests are made by a competent person and the interests of both parties to the contract are properly protected, buying in accordance with specifications is the best and fairest way to obtain a satisfactory supply of coal.

Heat quantities may be expressed by any of its measurable effects but the most convenient is the alteration of temperature.

Surface Condensation for Steam Turbines*

Coefficient of Heat Transference, Influence of Air Leakage, Condenser Pumps, Temperature of Air and Water and Contra vs. Ordinary Flow

BY PROFESSOR E. JOSSE

On shipboard surface condensers are always preferred because the condensed water should be fit for use as boiler feed. Even in stationary-turbine plants preference is often given to the surface condenser over the more economical jet condensers for three reasons: (1) the surface condenser produces a good vacuum more easily than the jet condenser; (2) the condensed water is free from oil and can be reused; (3) there is danger that the cooling water of the jet condenser might flow back into the turbine. Messrs. Tosi, of Leghorn, are installing an air-operated nonreturn valve to obviate this difficulty. As a rule surface condensers

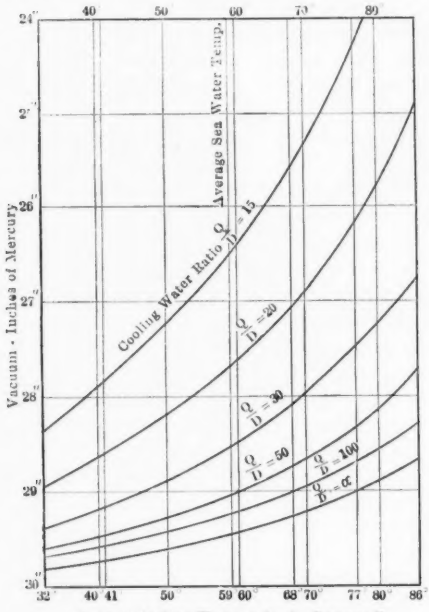

Vacuum - Inches of Mercury
Average Sea Water Temp.
Cooling Water Ratio Q/D = 15
Q/D = 20
Q/D = 30
Q/D = 50
Q/D = 100
Q/D = ∞
Ratio of Cooling Water to Feed - Degrees F.

FIG. 1

are insisted upon for turbines and they may cost from 30 to 60 per cent. of the whole turbine-plant cost. On board ship the large dimensions and weight are factors of importance.

An investigation was made of the effect of increasing vacuum on the thermal efficiency of the prime mover, bringing out the facts that the available heat increases considerably as the vacuum increases above 21 inches. The reason is that the specific volume of the steam augments rapidly as the condenser pressure is reduced, and the cylinders of reciprocating engines cannot for practical reasons be enlarged to accommodate this volume. It is well known that reducing the vacuum below 26 inches does not increase the efficiency of steam engines. In turbines there is ample steam space for large volumes and the lower condenser pressures can be fully utilized. These investigations proved that the engineer is on the right track when he endeavors further to improve the condenser vacuum. What can be achieved by enlarging the condenser dimensions has already been done and it is no good to go farther in this direction. Other ways must be found.

The attainable vacuum depends on the temperature and mass of the available cooling water. Given an unlimited amount of cooling water at 60 degrees Fahrenheit, the steam pressure can be reduced to half an inch absolute, or a 98 per cent. vacuum. With warmer circulating water, the vacuum will, of course, be poorer. In Fig. 1 are plotted the possible vacua with various ratios of circulating water to condensed steam and various initial temperatures. On board ship a ratio of 50 to 60 can generally be managed and an excellent vacuum should hence be realizable, if other considerations did not complicate the problem.

Coefficient of Heat Transference

In order that the steam may give off its heat to the cooling water, the heat has to pass through the metallic wall of the condenser tube and may be considered in three stages: in the transference from the steam to the metal; in the metallic wall of thickness d and thermal conductivity L; and in the transference from the metal to the water. The coefficient of transference U, the number of heat units transferred per hour through 1 square foot of metallic condenser wall when the temperature of the steam is 1 degree Fahrenheit higher than that of the water, can be deduced from the formula

$$\frac{1}{U} = \frac{1}{A_1} + \frac{d}{L} + \frac{1}{A_2},$$

d being the usual thickness of condenser tubes (1 millimeter or 0.0393 inch). For this thickness the value of L is fairly well known and may be given as 18,430 for brass, 61,500 for copper, 11,270 for iron, 5740 for zinc, 11,050 for tin and 2660 for aluminum. The middle term $\frac{d}{L}$ would have the value of $\frac{1}{18{,}430}$ and be of comparatively little importance.

The term $\frac{1}{A_2}$ is the most important and has been investigated with the aid of two concentric tubes, water being sent both through the inner tube and the annular jacket. The values of various experimenters differ greatly. Professor

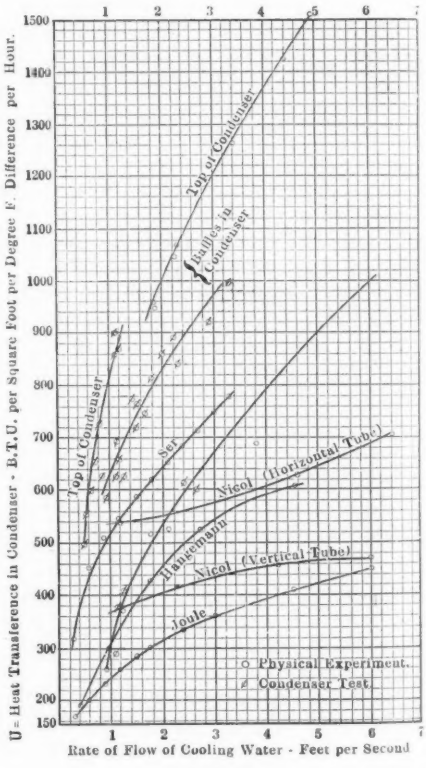

U = Heat Transference in Condenser - B.T.U. per Square Foot per Degree F. Difference per Hour.
Top of Condenser
Baffles in Condenser
Top of Condenser
Ser
Nicol (Horizontal Tube)
Hagenmann
Nicol (Vertical Tube)
Joule
Physical Experiment.
Condenser Test.
Rate of Flow of Cooling Water - Feet per Second

FIG. 2

Josse agrees best with Ser, who gave the approximate formula

$$A - 2 = 510\sqrt{V},$$

where V is the velocity of water through the tubes in feet per second. This velocity is the decisive factor; far more important than the material of the condenser tubes and their thickness, and also of greater consequence than the velocity of the steam, about which, or, rather, the term $\frac{1}{A_1}$, there is even less agreement. The coefficient A_1 is generally supposed to be about 2085, although Ser gives a much higher figure. From an analysis of Ser's figures and his own experiments,

*Abstract of paper read before the summer meeting of the Schiffsbautechnische Gesellschaft at Berlin, June 16 to 18, 1908, by Prof. E. Josse, director of the department of engineering at the Technical High School at Charlottenburg.

Professor Josse concludes that 3900 is a more correct value. The velocity of the steam has its influence, but the whole term does not count for much. For water flowing at the rate of 1.64 feet per second Josse's formula would be:

$$\frac{1}{U} = \frac{1}{3900} + \frac{1}{18{,}430} + \frac{1}{653} = \frac{1}{445}$$

and

$$U = 445.$$

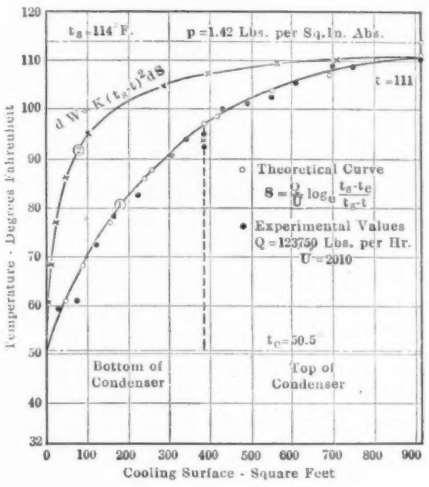


FIG. 3

If A_1 be increased to twice its value U would rise only to 475, and if the tube thickness be increased to 2 millimeters U would hardly be affected. An increase, however, in the rate of flow from 1.64 to 5 feet per second would raise U to 625. As an increase of the steam flow is undesirable the best plan is to accelerate the flow of the circulating water and by introducing the baffle strips or retarders of Pape, Henneberg & Co., of Hamburg, into his condenser tubes, in order to break the water currents up into vortices, he raised the U at a velocity of 3.28 feet per second from 614 to 922. The results of Professor Josse's experiments conducted with condensers and of experiments made by others with physical apparatus are plotted in Fig. 2, the curves showing that in condenser tests better results are obtained than in experiments conducted in the physical laboratory.

Opinions differ concerning the increase of U with greater differences of temperature. According to some the heat transferred should increase proportionately to the difference; according to Weiss and others, proportionally to the square of the temperature differences. His investigations were conducted by placing thermo couples in different portions of the condenser tubes. If the heat transferred increases as a linear function of the difference then the rise of the temperature in the cooling water should follow an exponential law and it was found to be so.

The curves in Fig. 3 are in equally close agreement with the formula

$$Surface = S = \frac{Q}{U} \log_e \frac{t_s - t_e}{t_s - t},$$

where t_s is the saturation temperature and t_e the temperature of the cooling water at entrance, t being the discharge temperature. It will be seen that the quadratic formula of Weiss does not conform at all with the theoretic curve.

Influence of Air Leakage

Before proceeding to a calculation of suitable condenser dimensions the influence of air leakage must be studied. Air passes into the condenser with the exhaust steam, the temperature of the air being that of the steam; the pressure of the mixture will be the sum of the partial steam pressure and of the partial air pressure. The air must be withdrawn by the air pump. If the withdrawal takes place at the temperature corresponding to the condenser pressure the partial steam pressure would be equal to the condenser pressure; that is, the partial air pressure would be zero and the pump would have to deal with an enormous air volume. The air pressure should, therefore, not be reduced to zero and the temperature be lowered, at the spot where the air is withdrawn, below the saturation temperature of the condenser pressure. The condenser is to cool the air as well as the steam, for while the heat transference from steam to metal takes place readily, the respective coefficient U being in round numbers 4100, air is known to be a good thermal insulator and its U is of the order of 1.

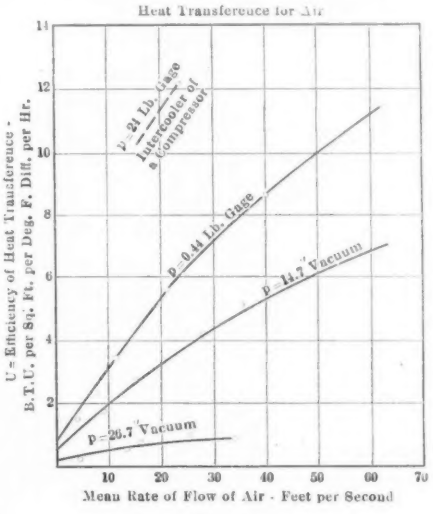

Heat Transference for Air
p=21 Lb. Gage Intercooler of 8 Compressor
p=0.44 Lb. Gage
p=14.7" Vacuum
p=26.7" Vacuum
U=Efficiency of Heat Transference - B.T.U. per Sq. Ft. per Deg. F. Diff. per Hr.
Mean Rate of Flow of Air - Feet per Second

FIG. 4

Experiments on the heating of air when passing along pipes have been made by Ser. He noticed that the U improves with the diameter of the pipes, and also with the velocity of the air (his pipe diameters range from 10 to 50 millimeters), but he did not introduce a diameter term in his empirical formula, and all his experiments were conducted at ordinary air pressure.

In the condenser vacuum the heat transference should obviously be smaller than at atmospheric pressure and Professor Josse investigated this problem by passing air at different speeds and pressures through a pipe of 23 millimeters internal diameter and 1320 millimeters in length placed in a steam bath at 212 degrees Fahrenheit. The air was drawn by a pump through a meter, its volume determined and its pressure adjusted by means of a valve inserted between the meter and the pipe. The heat transference from the steam through the pipe wall to the air was reduced from the heat of the air and checked by determining the amount of condensation taking place in the steam jacket.

Figs. 4 and 5 and the accompanying table show the results in a striking manner, the experiments indicating that the rate of flow of the water which is decisive for the cooling of the steam will be of little consequence for the cooling of the air, which will essentially depend upon the rate of the flow of the air, in consequence of which large air-cooling surfaces should be provided.

The curves of Fig. 6 illustrate the rise in the temperature and the cooling water resulting when different amounts of air enter the condenser. In both cases, the first portion of the curve is horizontal, i.e., there is no temperature rise at first. In the lower curve about 40 per cent. of the total condenser surface seems to have essentially served for cooling the air, since if the exhaust were free of air the curve would at once rise.

In steam turbines it is more easy to keep air out than in reciprocating engines. In turbines air can only gain access, as a rule, through the shaft glands, which are packed with water, oil or steam. Steam turbines are, however, as liable as reciprocating engines to air contamination through the feed water, if the pipes are leaky or the pumps do not work well.

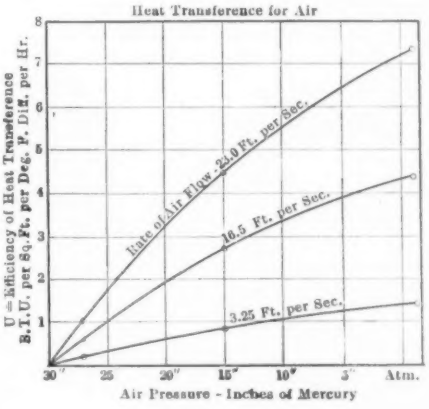

Heat Transference for Air
Rate of Air Flow 24.0 Ft. per Sec.
16.5 Ft. per Sec.
3.25 Ft. per Sec.
U=Efficiency of Heat Transference - B.T.U. per Sq. Ft. per Deg. F. Diff. per Hr.
Air Pressure - Inches of Mercury
Atm.

FIG. 5

Yet with well constructed turbines the amount of air leakage should be very small. Experiments with a 300-kilowatt Parsons turbine show that not more than ½ pound of air was delivered per hour when 6600 pounds of steam was used per hour.

Condenser Pumps

Passing to the condenser pumps, Professor Josse points out that the air and

condensed water may either be removed separately, by a so-called dry-air pump, or both together, by a wet-air pump. As dry-air pumps have to deal with high compression ratios, with high vacua and single-stage pumps, the clearances must be small. When the clearance amounts to 5 per cent. the vacuum cannot be maintained at more

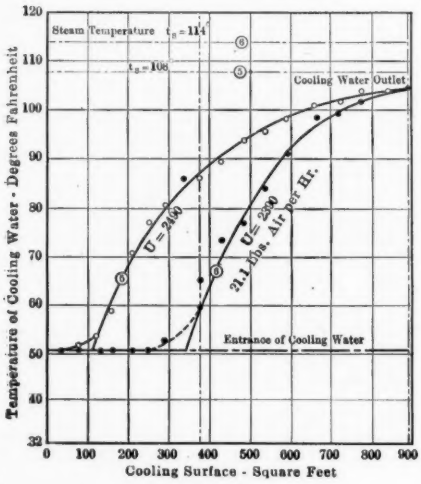

Steam Temperature $t_s = 114$
$t_s = 108$
Cooling Water Outlet
U = 2490
U = 2290
21.1 Lbs. Air per Hr.
Entrance of Cooling Water
Temperature of Cooling Water - Degrees Fahrenheit
Cooling Surface - Square Feet

FIG. 6

than 95 per cent. and the clearance must be reduced, or other expedients adopted. Three are mentioned: (1) the air pump may be built in two stages; (2) the pump may be fitted with an equalizing pipe so that the two sides of the piston are connected near the end of each stroke, the volumetric efficiency is raised by this expedient, but considerable more power is absorbed to accomplish the result; (3) with the wet-air pump the clearance space is made to receive the condensed water which will fill at least part of it.

Fig. 7 illustrates the construction of these double-acting wet-air pumps. It will be noted that means are provided in the upper valve deck to allow the non-condensable vapors to enter above the piston on each down stroke, together with the water which flows in through the center ports passed over by the piston.

A pump of this design, 20 inches in diameter, 6.3 inches stroke and running at 250 revolutions per minute, for a plant condensing 22,000 pounds of steam per hour with a vacuum of 28 inches, was also illustrated. It is important in this pump that the valves should be very light in weight.

Temperature of Discharged Air

Returning to the temperature at which the mixture of condensed water and air should be withdrawn, the case represented

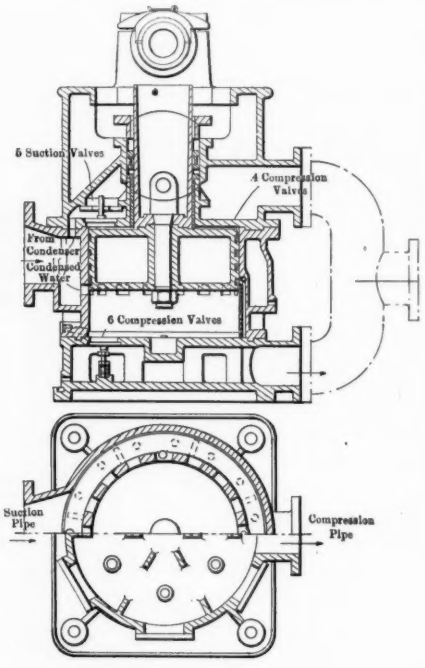


FIG. 7

in Fig. 8 is that of a 28½-inch vacuum, one kilogram of air entering per hour, and the air-pump capacity is 50 cubic meters, 1765 cubic feet per hour. The abscissas are the temperatures at the condenser outlet. If the pump is merely to remove the dry air the flow of air would be little influenced by the temperature, as the straight line in the upper part of the diagram indicates, but the partial pressure of the air at saturation temperature dwindles to zero and the air volume becomes very great.

In the case represented the volume to be removed would equal the pump capacity of 50 cubic meters at 25.6 degrees Centigrade, when the partial air pressure will be 0.017 atmosphere. If the pump had a capacity of 2800 cubic feet, or 80 cubic meters per hour, then the temperature might rise to 29 degrees Centigrade. If, on the other hand, two kilograms of air should leak into the condenser instead of one, the cooling would be carried down to 15 degrees Centigrade.

The temperature of the discharged air is a criterion as to the fitness of the con-

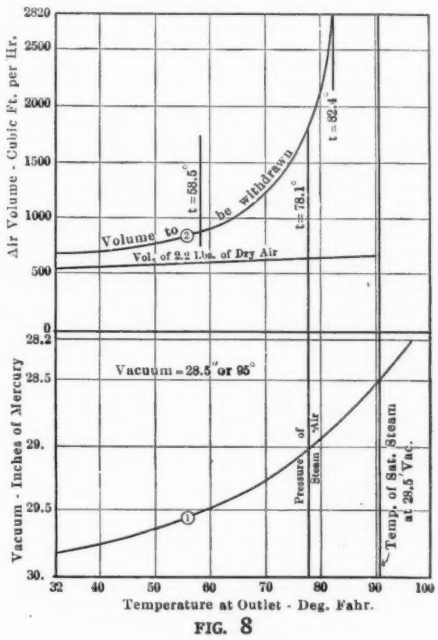

Air Volume - Cubic Ft. per Hr.
t = 82.4
t = 58.5
t = 78.1
Volume to be withdrawn
Volume to
Vol. of 2.2 Lbs. of Dry Air
Vacuum = 28.5" or 95°
Pressure of Steam - Air
Temp. of Sat. Steam at 28.5 Vac.
Vacuum - Inches of Mercury
Temperature at Outlet - Deg. Fahr.

FIG. 8

denser plant, but caution should be exercised in forming an opinion. A claim that the condenser must work the better the lower the temperature of the discharged air is unjustified. The air temperature may be low because there is much air leakage, or because the pump delivery is poor. Air leakage becomes a serious factor when a high vacuum is to be utilized and the air must be cooled whether a dry- or wet-air pump be used.

Temperature of Condensed Water

As regards temperature of condensed water the two systems differ. When the air is separately withdrawn the condensed water need not be cooled. When a wet-air pump is used extra cooling of the condensed mixture is necessary, lest an after escape of air ensue; Professor Josse first cools the liquid, then the air, by bringing it into contact with the liquid, as the cool-

HEAT TRANSFERENCE COEFFICIENTS FOR AIR.

Length of pipe, 52 inches; internal diameter, 0.91 inch; air-flushed surface, 148 square inches.

Experiment.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
					Inches of vac. =			14.4	14.4	14.5	14.6	14.4	26.8	26.75	26.8	26.8	26.8
Air pressure, lb. abs.	14.95	14.95	14.95	14.95	14.95	14.95	14.95	7.57	7.57	7.54	7.50	7.57	1.56	1.53	1.56	1.56	1.56
Steam temp., deg. F.	Always 212°																
Air temp. at entrance, deg. F.	62.1	62.4	65.1	67.5	68.6	70	67.5	67.5	67.1	67.3	68	68	80.5	86.4	87	90.5	97.8
Air temp. at discharge, deg. F.	138	144.5	156.2	160.8	164.3	161	171.1	149.7	165.2	164	174.6	183	161.7	183.8	184	189	184.1
Air temp., mean, deg. F.	100.5	104.1	110.3	114.9	116.7	114.9	119.4	108.5	116.7	117.6	121.2	125.7	122.1	134.8	136.4	140	141.9
Air wt. per hr., lb.	70.8	65.9	24.4	16.7	12.9	9.16	5.4	34.2	19.6	15.3	8.7	4.82	3.8	2.75	1.79	1.46	0.53
Air vol. per hr., cu.ft.	1000	656.5	351	242.2	187.2	132.9	79.1	986	572	451	268.1	142.9	543	409.5	262.1	215	77.7
Air speed in pipe, no. ft. per sec.	62.2	40.8	21.8	15.1	11.64	8.27	4.92	61.4	35.6	28	16.03	8.9	33.8	25.5	16.3	13.38	4.82
B.t.u. transferred, per hr.	1282	906	530	371	295	198	134	670	458	366	221	132	73.5	64.	41.3	34.4	10.8
Heat transferred, coeff. = U	10.52	8.56	5.51	4.02	3.29	2.17	1.59	6.67	5.15	4.22	2.72	1.79	0.85	0.955	0.62	0.565	0.172

ing of the water requires much smaller surfaces than the cooling of the air. This arrangement is said to save surface space. The extra cooling of the liquid is insofar undesirable, as the cold feed water has afterward to be reheated with modern high vacua which generally do not requite a cooling of more than a few degrees below saturation temperature. This loss of heat will not amount to more than 1 or 1½ per cent. of the heat of the feed water. The wet pumps are, on the whole, simpler, occupy less space, absorb less power than dry-air pumps. Another point is that the steam withdrawn, together with the air, has to be compressed; for this purpose injection is sometimes resorted to. In the wet pump the steam will condense again as soon as compression is begun.

A Series of Condenser Tests

Professor Josse's experiments have extended over three years, during which his improved condensers have been working satisfactorily.

The first series of tests concerns the 300-kilowatt Parsons turbines of the engineering laboratory at Charlottenburg, which a vertical pipe of ample dimensions connects with the surface condenser below. The wet-air pump of Professor Josse is driven by belting from an electric motor at 300 revolutions. The chief dimensions are as follows:

Cooling surface	958	sq. ft.
Tubes, diameter	0.79	in.
Tubes, thickness	0.04	in.
Tubes, length	90½	in.
Number of tubes (upper set)	346	
Number of tubes (lower set)	342	
Total	688	
Surface (upper set)	483½	sq. ft.
Surface (lower set)	477.9	sq. ft.
Total surface	961	sq. ft.
Total cross-section (upper tubes)	136	sq. in.
Total cross-section (lower tubes)	135	sq. in.

The average duty of the condenser was 35 kilograms of steam condensed per hour per square meter (7.15 pounds per square foot) of cooling surface. The excess of cooling over the theoretical at the highest vacuum was 16 per cent., with a 27-inch vacuum, which went down to 5 per cent. The difference in temperature between the temperature of the condenser and the discharged cooling water was generally less than 2 degrees Centigrade.

The average coefficient of heat transference was high to 600, even 800, although the rate of flow of the cooling water was, as a rule, only 0.4 of a meter per second (16 inches). This high efficiency is ascribed to the good services of the baffles. The cooling water was very pure and baffles had not required any cleaning in three years.

The second condenser experimented with was that of the 200-kilowatt turbine of the laboratory built at the Algemeine Elektricitats Gesellschaft. This condenser was built for experimental purposes and is of peculiar construction. It consists of 620 tubes, disposed in an upper and lower condenser; 189 of the tubes of the upper condenser run crosswise, their length being 588 millimeters (23 inches). The three sets of longitudinal tubes have each a length of 1200 millimeters (47 inches), a common internal diameter of 15 millimeters (0.59 inch), and a total cooling surface of 28.52 square meters (308 square feet). This small area is to condense 2000 kilograms (4400 pounds) of steam per hour, 65 kilograms per hour per square meter (13.3 pounds per square foot), nearly twice as much as the first condenser. The best vacuum reached was 96.4 per cent., and nearly 50 per cent. more than the theoretical amount of cooling water was needed for this performance. The wet pump was also too small. The heat transference was very good; the coefficient rose to 1470 in the case of the top tubes. For the condenser as a whole the heat transference was 786, when the cooling-water ratio was 50. The cross tubes were added to see whether vortices set up in the steam would raise the efficiency; no such effect was observed.

Contraflow and Ordinary Flow

Professor Josse then discusses the piping system connecting the pumps to the condensers, the main case being where a cooling-water ratio of only 21 could be obtained, in consequence of which the vacua were much lower than what they should be. He questioned also the justification of the general distinction between contraflow and ordinary flow. For the greater portion of the condenser there is a rise of temperature only on the water side, the temperature of the steam side remains that of the saturated steam and the term "contraflow" should, strictly speaking, only be applied if there is a temperature fall in the one direction and a corresponding temperature rise in the opposite direction. As far as the condensation is concerned, it is immaterial in which direction the water flows. The contraflow principle is, however, correct and necessary for the smaller portion of the condenser in which the condensed liquid is cooled together with the air; for the air must be withdrawn from the coldest spot. It seems inadvisable to attempt to direct the flow of the steam on the contraflow principle, as that would obtruct the steam flow and create a pressure difference between different portions of the condenser which would be injurious to the maintenance of high vacua.

Increasing the Efficiency and Capacity of Large Gas Engines by Cooling the Charge

By F. E. Junge

Professor Junkers, of the Technische Hochschule, of Aachen, Germany, has been conducting a long series of investigations to ascertain the influence of charge temperature on both the capacity and the reliability and economy of gas engines. Fig. 1 shows the theoretical difference in the internal working process of the same gas engine operated with and without cooling the charge. According to the figure, there is a gain in work output attainable as represented by the small area along the expansion line, and as a further result an all-round reduction of temperatures in the cyclic process is realized.

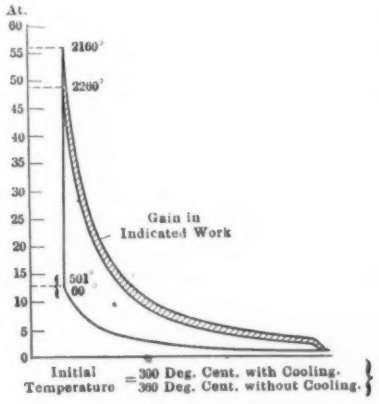


FIG. 1. THEORETICAL DIAGRAMS

The Junkers experiments were made on one of the Ochelhäuser two-stroke engines of the Hörder Verein, at Hörde, Westfalia. Fig. 2 gives a schematic view of the engine, which was described in detail in Power in 1906. The operation here differs from the usual mode in that scavenging air is not taken from a special pump as is done ordinarily, but from the blowing cylinder of a neighboring blast-furnace blowing engine. The cutoff-governing device connected with the air receptacle below provides for the introduction of the scavenging air in due time and quantity. The pump proper, which is directly connected to the back crosshead, delivers the ready-made mixture to the working cylinder through the overflow

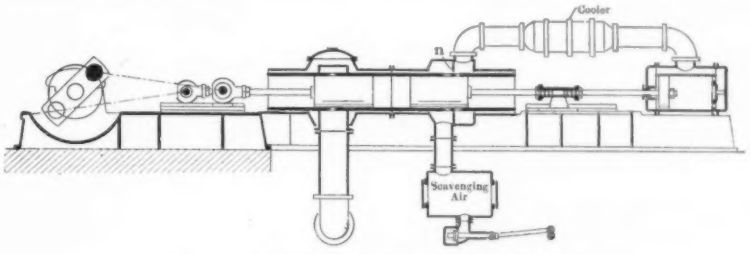


FIG. 2. OECHELHAUSER ENGINE AT HOERDE

pipe above, which is provided with a cooler, as shown in the sketch.

In the first trial the engine ran, without cooling the charge, at its maximum capacity, yielding a mean pressure in the working cylinder of 4.55 atmospheres and developing 395 indicated horsepower. The charge temperature was 90.5 degrees

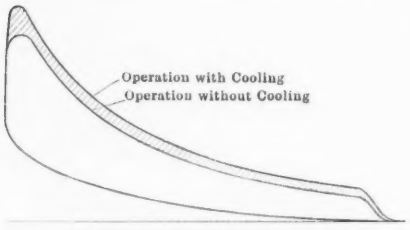


FIG. 3. ACTUAL DIAGRAMS TAKEN AT HOERDE

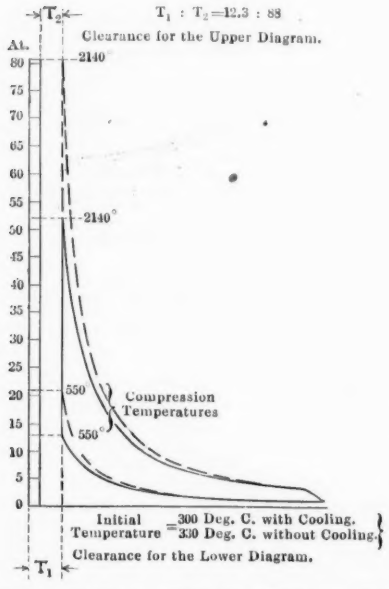

T_2
$T_1 : T_2 = 12.3 : 88$
Clearance for the Upper Diagram.
Compression Temperatures
Initial Temperature = 300 Deg. C. with Cooling. 330 Deg. C. without Cooling.
Clearance for the Lower Diagram.
T_1

FIG. 4. DIAGRAM SHOWING EFFECT OF MIXTURE COOLING ON COMPRESSION RATIO

grade. From this follows a theoretical increase of capacity, with cooling, of 0.198 of the amount attained without cooling. The practical increase was 0.165 of the ordinary result. In other words, when cooling the charge the engine showed an increased output of 17 per cent. beyond what was attainable without cooling.

Fig. 3 gives two diagrams plotted one above the other, the one taken without and the other with cooling. The pump work amounted to 55 indicated horsepower in the first and to 51 indicated horsepower in the second instance. But this difference is probably due to the fact that the charging pump was too large for ordinary operation and its intake had to be throttled, while, owing to the larger free volume taken when cooling, the throttle was opened and its resistance diminished. The cooler carried away approximately 38,500 heat units per hour from the charge. A comparison of heat absorption by cooling water with and without mixture cooling, respectively, gives the following results, it being assumed that 700 heat units per horsepower-hour were being carried away by the cooling water: Output without intercooling = 395 indicated horsepower; loss to cooling water of cylinder = 700 × 395 = 276,500 heat units per hour. Output with intercooling = 460 indicated horsepower, and it was ascertained that the heat loss to the cooling water for the cylinder was not larger than before, 276,500 heat units per hour. In addition, there were wasted 38,500 heat units for cooling, making a total of 315,000 heat units per hour. An engine not equipped with the cooling device would lose, for the same output of 460 horsepower, 460 × 700 = 322,000 heat units per hour. It follows that the cooling also has a favorable effect on the total heat carried away per unit of power developed.

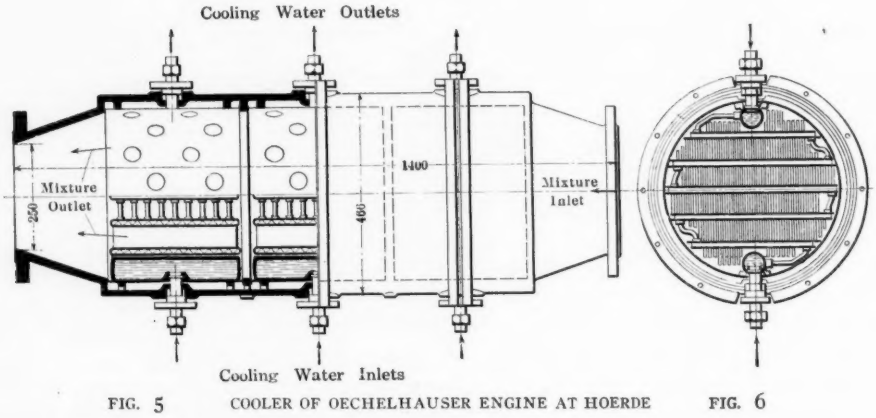


FIG. 5 COOLER OF OECHELHAUSER ENGINE AT HOERDE FIG. 6

process. But these advantages are not all that can be realized by the innovation of mixture cooling. If, instead of reducing the temperatures of the whole cyclic

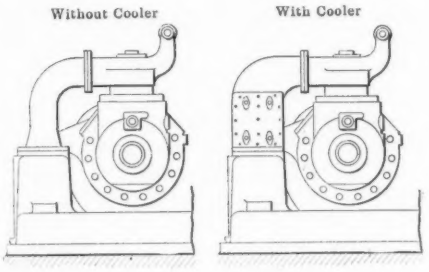
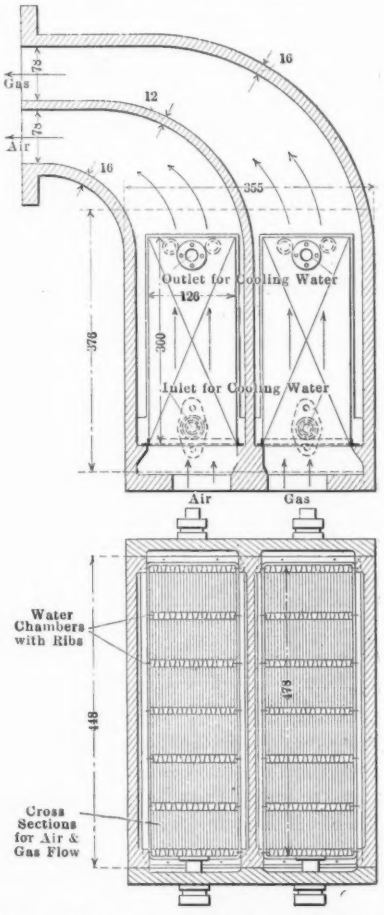


FIG. 7 FIG. 8

200-HORSEPOWER KOERTING ENGINE WITHOUT AND WITH COOLER



FIGS. 9 AND 10. EXPERIMENTAL COOLER FOR 200-HORSEPOWER KOERTING ENGINE

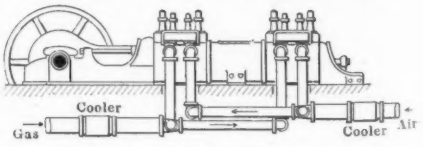


FIG. 11. FOUR-STROKE TANDEM ENGINE WITH COOLER

Centigrade. In the second trial the engine ran with cooling of the charge and yielded a mean pressure of 5.29 atmospheres, or 460 indicated horsepower in the working cylinder. The cooler reduced the charge temperature from 90.5 to 30.5 degrees Centigrade, the difference or refrigeration amounting, therefore, to 60 degrees Centi-

Among other advantages of the Junkers system may be mentioned that the number of misfires is reduced, whereby the average mechanical efficiency of the engine is increased. Also, part of the water vapor of the charge is separated out by the cooler, by condensation, which must have a favorable effect on the combustion

process, cooling is used for increasing the compression pressures, then a far greater capacity may yet be obtained. For instance, cooling the charge by only 30 degrees Centigrade allows an increase of compression pressure from 13 to about 21 atmospheres to be used, without thereby increasing the cylinder temperature above

that of ordinary engines. A Körting engine running on producer gas and driving an electric generator showed thus an increased capacity of 12 per cent. at the switchboard. The fact was also confirmed that preignition, which had been a weak feature of the particular installation, disappeared entirely when cooling the mixture.

As to the construction of the cooler, those surfaces which absorb the heat of the gases must bear the correct proportion to the others which conduct their heat to the cooling water. The coolers are made of copper and are tinplated. They are mounted in solid cast-iron casings in such manner that the reciprocating movements, which accompany the operation of large engines, do not impose unfavorable stresses on the cooling system. The coolers allow the gases to pass through without change of direction, and the path of their travel is short, so that the friction resistance is small.

Figs. 5 and 6 show the cooler used at the Hörde Verein. Figs. 7 and 8 show an arrangement of coolers used in connection with Körting engines. It will be evident that the appearance or floor space of the engine is not changed at all. The coolers are put in place from one side, like drawers, and can be removed for inspection and cleaning in a few moments after loosening the cover. Fig. 11 gives a schematic view of a tandem four-stroke engine with coolers built in both the air- and the gas-intake pipes. They show very favorable results, especially in summer; of course, it is impossible to realize such a considerable increase of capacity as with two-stroke engines, because the air is not compressed before it passes to the engine cylinder and the temperature differences are therefore smaller.

According to a contemporary, the turbinal tubeless boiler is made of concentric annular conical vessels with narrow water spaces and narrow flame spaces, heated by a liquid-fuel burner from below. The steam produced in the boiler proper descends through a helically coiled superheater tube placed in the middle space of the innermost cone. The issuing steam is dried and comes out at a high temperature, something that may be over 600 degrees Fahrenheit.

An interesting departure in steel-works practice is about to be begun by the United States Steel Corporation in the establishment of a bureau for scientific research near Duquesne, Penn. A laboratory is to be erected, the work starting in the spring, and experiments will be systematically carried on with the purpose of improving the processes and methods of steel manufacture for the benefit of the various constituent companies of the United States Steel Corporation.

Tests of Run-of-Mine Coal and Coal Briquets

A bulletin on the comparative tests of run-of-mine coal and coal briquets on locomotives and on a torpedo boat has just been issued by the technologic branch of the United States Geological Survey. The author of the bulletin, W. F. M. Goss, consulting engineer of briquet tests, gives the results of the tests in the following:

1. The briquets made on the Government's machines have well withstood exposure to the weather and have suffered but little deterioration from handling.

2. In all classes of service involved by the experiments, the use of briquets in the place of natural coal appears to have increased the evaporative efficiency of the boilers tested.

3. The smoke produced has in no test been more dense with the briquets than with coal; on the contrary, in most tests the smoke density is said to have been less when briquets were used.

4. The use of briquets increases the facility with which an even fire over the whole area of the grate may be maintained.

5. In locomotive service the substitution of briquets for coal has resulted in a marked increase in efficiency, in an increase of boiler capacity, and in a decrease in the production of smoke. It has been especially noted that careful firing of briquets at terminals is effective in diminishing the amount of smoke produced.

6. In torpedo-boat service the substitution of briquets for coal improves the evaporative efficiency of the boiler. It does not appear to have affected favorably or otherwise the amount of smoke produced. The briquets used in this series of tests were of a form requiring considerable bunker capacity for their storage, but as the form of the briquet is a detail entirely within control, this objection need not apply to the use of the briquets in actual service.

The tests of the coal and briquets on the locomotives were made under the direction of A. W. Gibbs, general superintendent of motive power of the Pennsylvania lines, by E. D. Nelson, engineer of tests, at Altoona, Penn., in coöperation with the technologic branch of the Geological Survey, which sampled the coal and manufactured the briquets.

Many low-volatile coals, such as those mined in the vicinity of Johnstown, Penn., are semismokeless and therefore very desirable for use in locomotives at or near terminals; nevertheless, on account of their low evaporative efficiency, they have not been found altogether satisfactory when used as locomotive fuel. Their tendency to disintegrate rapidly on the grate during combustion causes large quantities of cinders and sparks of high calorific value to be discharged. These cinders accumulate in the smokebox of the locomotive, obstruct the draft on the fires, and reduce the capacity of the boiler. The investigation here reported, therefore, was undertaken to determine in what measure, if any, the briquet process will serve as a remedy for these defects and to discover the effect of the process on efficiency and capacity.

The coal selected for the tests was taken from a mine working the Lower Kittanning coalbed near Lloydell, Penn., on the South Fork branch of the Pennsylvania railroad. Its characteristics as a locomotive fuel were therefore well known. The Lloydell coal is a very friable, low-volatile bituminous coal, and the carloads selected for the tests consisted of run-of-mine. They were loaded and shipped under the direction of J. S. Burrows, of the Geological Survey. The coal was exposed to the weather for thirty days on the way to the St. Louis testing plant, before being made into briquets. It showed but little change due to this exposure except a decided increase in moisture, which, however, was eliminated in the briquet process.

The binding material in all the briquets was water-gas pitch. This material was furnished at the briquet plant of the United States Geological Survey, in St. Louis, at $9 per ton, or 0.45 cent per pound. The least amount of binding material that would make perfect briquets was found to be 5 per cent. of the weight of the coal. The cost of the binder in one ton of the 5 per cent. briquets was, therefore, 45 cents.

The cost of the briquet process, including all charges, is estimated to be about $1 per ton of briquets; that is, the briquet process added approximately $1 per ton to the cost of the coal. The briquets were made, however, in an experimental plant, and the price is for this reason probably not so low as if they had been made on a much larger scale.

The briquets were made by the fuel-testing plant of the United States Geological Survey at St. Louis. The coal was shipped from the mine at Lloydell under the supervision of an inspector of the Survey, who at the same time obtained mine samples. The samples were hermetically sealed and sent to the St. Louis laboratories for analysis. After the coal was made up into briquets it was returned to the locomotive-testing plant at Altoona for the tests.

To observe the effect on briquets of exposure to the weather, a number of the round and square briquets were placed on the roof of the testing plant. After four months of exposure for the round and three months for the square briquets, no change whatever from their original condition was noticed. They appeared to be entirely impervious to moisture and were still firm and hard.

The briquets were little affected by handling. They were loaded at St. Louis in open gondola cars and shipped to

Altoona, where they were unloaded by hand and stacked. They were handled a third time in taking them to the firing platform of the test locomotive. After these three handlings they were still in good condition, very few were broken, and the amount of dust and small particles was practically negligible.

Conclusions Reached

The results of the tests justify the following conclusions:

(a) The evaporation per pound of fuel is greater for the Lloydell coal briquets than for the same coal in its natural state. This advantage is maintained at all rates of evaporation.

(b) The capacity of the boiler is considerably increased by the use of coal briquets.

(c) The briquet process appears to have little effect in reducing the quantity of cinders and sparks; the calorific value of these, however, is not so high in the briquets as in the natural fuel.

(d) The density of the smoke with the coal briquets is much less than with the natural coal.

(e) The percentage of binder in the briquet has little influence on smoke density.

(f) The percentage of binder for the range tested appears to have little or no influence on the evaporative efficiency.

(g) The expense of the briquet process under the conditions of the experiments adds about $1 per ton to the price of the fuel, an amount which does not seem to be warranted by the resulting increase in evaporative efficiency.

(h) With careful firing, the briquets can be used at terminals with a considerable decrease in smoke.

(i) The briquets appear to withstand well exposure to the weather, and suffer little deterioration from handling.

Western-coal Briquets

In coöperation with the Missouri Pacific, the Lake Shore & Michigan Southern, the Michigan Central, the Chicago, Rock Island & Pacific, the Chicago, Burlington & Quincy, and the Chicago & Eastern Illinois railroads, 100 locomotive tests have been made by the United States Geological Survey to determine the value, as a locomotive fuel, of briquets made from a large number of Western coals. All tests were made on locomotives in actual service on the road. In some tests there was small opportunity for procuring elaborate data, but in others, where dynamometer cars were employed, it was possible to obtain more detailed results. The purpose which these tests were intended to serve was not so much to determine the evaporative efficiency of briquets as to investigate their behavior in practical use.

Briquets made from Arkansas semi-anthracite, two qualities of Indian Territory slack, Indian Territory screenings, Missouri slack, Indiana Brazil block slack, coke breeze, and a mixture of coke breeze and washed Illinois coal were tested, and comparisons were drawn either with the same coal that was used in the briquet or with coal similar to it. In nearly every test the results reported show that the coal when burned in the form of briquets gives a higher evaporative efficiency than when burned in the natural state.

For example, Indian Territory screenings give a boiler efficiency of 59 per cent., whereas briquets made from the same coal give an efficiency of 65 to 67 per cent. Decrease in smoke density, the elimination of objectionable clinkers, and an apparent decrease in the quantity of cinders and sparks are named as the chief reasons for this increased efficiency.

An Obscure Armature Trouble

By H. F. Rudolph

The following case of motor trouble caused much worry to the electrical force in an industrial plant and was finally brought to the attention of the writer, who found the cause of trouble more through accident than anything else. A 6-horse-power series-wound direct-current crane motor had a winding of a peculiar character; the coils, instead of being form-wound, were hand-wound directly in the slots and the winding was so arranged that the finishing end of the wire in each coil was connected to the bottom of the cummutator bar, after which the beginning end of the coil was brought through the slot and connected to the top of the commutator bar. The armature winding was wave-connected, with two brushes; the machine was a four-pole motor, and the brush holders were so located that the top connection from each of the armature slots led to the commutator bar directly opposite (Fig. 1). This motor burned off two or three end connections per week at the point x in the sketch and no amount of investigation supplied any clue to the cause of the trouble. A new armature was finally procured from the makers, which developed the same trouble, burning off four end connections the first week. The motor was not overloaded, and the field-magnet coils were not partly burned out, so the motor was kept going for some time by repairing the spare armature and changing armatures every few days. Finally the coils were all disconnected from the commutator and individually tested for grounds, short-circuits or loose connections, and a bar-to-bar test of the commutator was made with a 10,000-ohm magneto. No trouble being found, the armature was reconnected and put back in service; it burned off four leads the first day.

We gave up in despair and appealed to the manufacturers, who suggested that expansion and contraction of the wire might be the cause and suggested the change indicated in Fig. 2. The wires were cut at S and new pieces of a larger size spliced on and loops for expansion left at the commutator end. A band of twine was wound on next to the commutator and the armature replaced in the motor, where it promptly burned out six coils completely. The design of the winding was such that replacing six coils involved the complete rewinding of the armature.

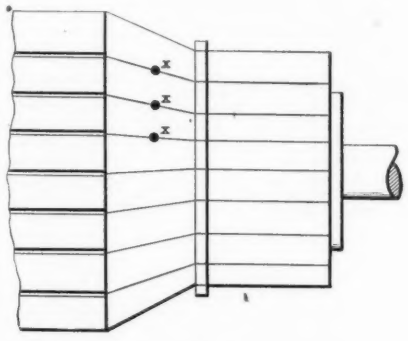


FIG. 1

This was done and before the commutator was replaced it was again tested for short-circuited bars, this time with 110 volts instead of the magneto. Upon the application of the current the mica at first smoked and finally became red hot, remaining so until the current was withdrawn. As all bars tested the same, new mica was placed in the commutator and the armature connected and put in service, where it remained for six months without a sign of trouble.

In the meantime the spare armature was tested and, the mica proving defective, new mica was inserted and the old armature coils reconnected. In order to satisfy ourselves that it was the new mica and not the new coils that cured the trouble, the armatures were again changed, but not a sign of trouble has been seen, although the old armature has been in service three months.

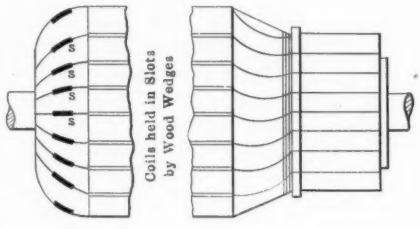


FIG. 2

The United States Civil Service Commission announces an examination on February 17 to secure eligibles for a vacancy in the position of engineer (competent to take care of a pumping plant, tank house, etc.) in the Indian service at Fort Berthold, North Dakota.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Low Pressure Turbines and Steam Engines

The article in the January 5 issue, by J. R. Bibbins, states that "Professor Rateau's work in steel-mill and mine hoisting has also resulted in the practical application of low-pressure turbines in connection with the steam-regenerative principle, permitting the turbines to operate constantly, using the exhaust steam from engines intermittently operative. His work has been brought to our notice in this country by H. H. Wait in discussing regenerative application to steel mills. (American Institute of Electrical Engineers, December, 1907.)"

Mr. Bibbins' statement is undoubtedly correct as to his personal knowledge of the question, but I wish to say that I introduced Professor Rateau's steam-regenerative principle in America, and have been working to develop it since 1903.

In 1904, Professor Rateau himself presented to the American Society of Mechanical Engineers, at a meeting held in Chicago, a paper on "Different Applications of Steam Turbines." This paper fully described his regenerative system and gave illustrations of what had been done by him previous to his coming to America.

On September 21, 1904, I read a paper before the Western Society of Engineers, entitled, "Utilization of Exhaust Steam in Connection with Low-Pressure Steam Turbines," and in October, 1905, I also read a paper before the Lake Superior Mining Institute, entitled, "The Utilization of Exhaust Steam from Rolling-Mill Engines, Hoisting Engines, etc., by Means of Steam Regenerators and Low-Pressure Turbines on the Rateau System."

The International Harvester Company's plant described by Mr. Wait, in his paper before the American Institute of Electrical Engineers, was put up by the Rateau Steam Regenerator Company, which was the sole contractor for the entire equipment. This same company has also acted as sole contractor for the Vandergrift plant of the American Sheet and Tin Plate Company. These two plants are the only ones in America utilizing the steam-regenerative principle. They are also the only plants in this country where the exhaust of intermittent-running engines is compounded with low-pressure turbines.

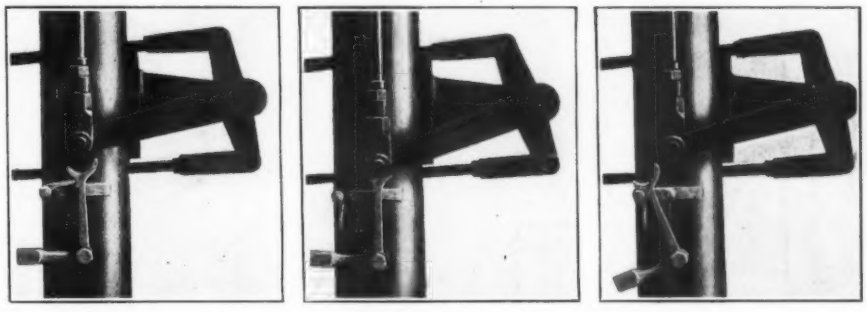
Incidentally I should like to remark that two of the most complete and striking articles regarding the use of exhaust steam in low-pressure turbines were published in POWER; one by F. G. Gasche, entitled, "First Rateau Regenerator Installed in America," and one by Professor Rateau in the issue of October, 1907, under the heading, "Compounding Piston Engines with Turbines."

I strongly agree with Mr. Bibbins when he mentions J. W. Kirkland in connection with low-pressure turbine work, as no one admires more than I do the splendid missionary work done by Mr. Kirkland on this subject.

L. BATTU,
President, Rateau Steam Regenerator Co.
New York City.

A Safety Stop

The stop shown in the accompanying illustration was made and put on by W. A. Bright, foreman of the Decatur Novelty Works, and is a neat little device. It is intended to take the place of the pin used on some Corliss-engine governors.



THE BRIGHT SAFETY STOP

The device is very simple and any engineer can make and attach one himself. The illustration shows three positions. The first is that in which the stop is placed just after closing the throttle and before the speed is much reduced. It will be noted that the fork is not directly under the end of the rod that comes down from the collar. As this rod drops, the fork centers and allows the small dog to drop as shown in the second view. When the engine is again brought up to speed the rod rises, and the fork is pulled over to one side out of the way by the weighted end as shown in the third view. This leaves a clear path for the rod should anything happen to stop the governor.

ETHAN VIALL.

Decatur, Ill.

Selection and Safety of Pipe Fittings

In the issue of December 15 there is an article on "Selection and Safety of Pipe Fittings," by A. J. Dixon, in which there appears to me to be a mistake. On page 994, in figuring the stress on the cap screws of the bonnet of the angle valve, he has added the stress due to tightening the cap screws to that of the steam pressure on the under side of the bonnet, which I do not think is correct.

Taking the figures given in his article, the total stress due to the steam pressure is 3178.56 pounds, and that due to tightening cap screws 2687.5 pounds, which he adds together to get the total stress.

The steam pressure can add no stress to the cap screws until it exceeds that due to the screwing down of the cap screws, as up to this point the two pressures are opposed and will be balanced when one is equal to the other. In this case the stress due to the steam pressure is greater than the initial stress on the cap screws, so that the stress added by the steam pressure would be only the difference between the two pressures, or a total of that due to the steam pressure only, or 3178.56 pounds, a stress of 529.76 pounds for each screw instead of 977.68 pounds, as given in his article.

In a case where the initial stress due to screwing down the cap screws exceeded that due to the steam pressure, there would be no additional stress on the

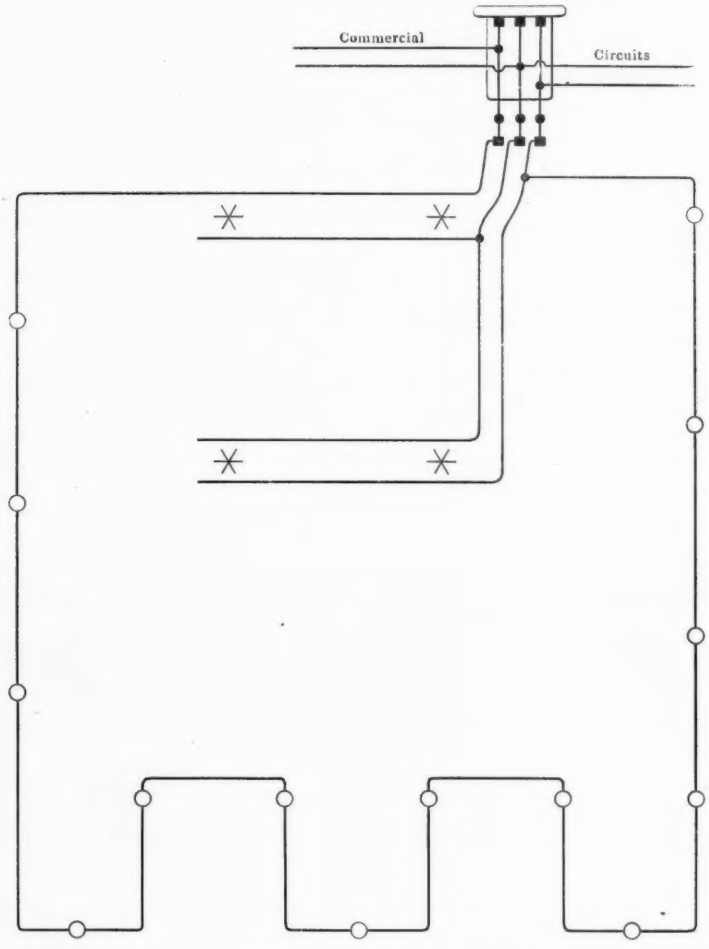
screws upon admitting steam to the valve.

W. O. PERKINS.

Bristol, Conn.

A Lighting Problem

The accompanying sketch shows the proposed circuit-arrangement for a small country town which is going to be lighted from a larger town several miles away. The public square has a multiple-arc lamp at each corner, indicated by the crosses; the rest of the lamps, indicated by circles, are series tungsten incandescents, fourteen in number. The town being small, it is proposed to use a three-wire circuit and connect two of the arcs on each side of the neutral wire and the series lamps on a separate circuit. I suggested connecting them as shown in the diagram; as a time switch will be put in to handle the street lights, this will save a switch.



PROPOSED LIGHTING CIRCUIT

It is also proposed to run secondary circuits for commercial lighting, as in the diagram, instead of running three wires both ways.

I would be glad to have the opinion of some other readers as to how they would connect these circuits and run the commercial lines, and whether they think the diagram shows a feasible plan.

F. L. ROLPH.

Indianola, Ill.

Keeping Plant Records

Not very long ago the editors of POWER AND THE ENGINEER strongly urged the operating engineer to keep records from which to compute the cost of his plant output, but in the issue of December 8 they disparage the only means many of us have of keeping such records. While the criticisms in this latter editorial are doubtless well founded, it is nevertheless true that the periodical reading of switchboard instruments and the ordinary methods of measuring water and weighing coal can be made to give valuable results. Two years of experience with the methods under discussion have demonstrated to me that with careful readings and familiarity with the plant a reasonably close deduction can be made of the cost of output, even when elevator service, heating, etc., have to be taken into account. I have wished that some small-plant man would tell how he keeps his records, but perhaps they all think that without automatic recorders and special apparatus it would be useless to try to come anywhere near any useful figures.

We have no way of weighing the coal automatically; even the man who wanted to sell us a machine said it could not be installed owing to lack of head room. However, by many tests of the barrow capacity which are made at frequent intervals, I find that we get what we pay for in pounds, though not always in quality. As to the water, I have done nothing yet to verify the meter, but expect to do so before long. For obtaining an idea of the output, we have found reading the ammeter once an hour is often enough, as the load comes on gradually and remains at practically one point from 10:30 a.m. until 5 p.m., and then falls off gradually.

The voltage is kept constant and the load in amperes is put down each hour on a log sheet. The next morning I figure the total ampere-hours of the day's run. It is also noted on the sheet when engines are put on and taken off, so that the difference in their consumption of steam can be taken into account. The ampere-hours, the number of hours run, the kilowatt-hours and the percentage of the rated load made by the Corliss and the automatic engines are put down so as to be seen at a glance. The number of barrows of coal and ashes is also added and this completes the log sheet for one day. Saturday's sheet also shows all of the items for the week and the sheet for the last day of the month contains them for the whole month, as well as the coal delivered to the plant, the water (by ordinary meter) evaporated, and that used for blowing down and washing out the boilers and heater, the average tons of coal burned per day, the percentage of ashes to coal and the number of loads of ashes which we must pay to have removed.

From the records mentioned I figure how much of the coal, etc., must be charged to lights, and I do not think I am seriously out on the cost per kilowatt-hour.

Of course, by this system one cannot tell exactly the evaporation per pound of coal, but having the coal company's bill, the water bill, the supplies bill, the payroll and a good idea of the number of kilowatt-hours generated, I am able to tell very nearly what the costs are. Any engineer who has not tried it before will find keeping plant records more interesting than any other branch of his work.

A. N. BOGART.

New York City.

[We are glad to learn of Mr. Bogart's excellent work in the systematic keeping of plant records, and we admit, most cheerfully, that the methods under discussion *may* be made to yield fairly satisfactory results under the close supervision of a painstaking chief. Our experience, however, is that unless the supervision is exercised to a burdensome degree, records taken as described become

slovenly and unreliable. However, our criticism was directed at the plant owners who fail to provide adequate facilities, not at the engineers, like Mr. Bogart, who do the best they can with what they have.—EDITORS.]

A Station Load Indicator

In an electric-light plant with which I am connected it is necessary for the engine-room force to know at all times the load on the station. For this purpose, there was formerly mounted on the switchboard-gallery railing a frame having card figures to indicate the load. As

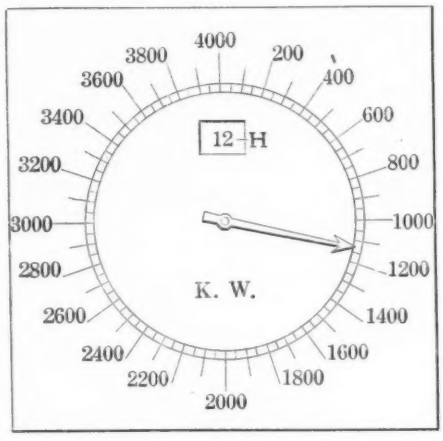


FIG. 1

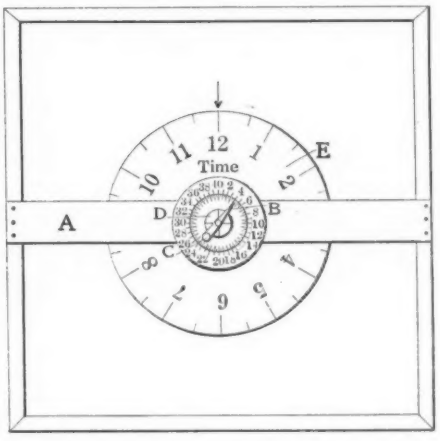


FIG. 2

it was inconvenient for the switchboard operator to change the cards every half hour, I devised a dial indicator, as shown in the accompanying sketches. Fig. 1 is a face view and Fig. 2 a back view.

It consists of a piece of sheet iron 30 inches square, mounted on a light wooden frame. The dial scale and figures are painted white on a black background; the pointer is gilded. Across the back a strip *A* is fastened, leaving a space of about 2 inches between the strip and the sheet iron. Through the center of the strip *A* and the sheet iron is passed a short piece of ½-inch pipe just long enough to reach through with room for locknuts on each end to hold it in place. Through this pipe is passed a piece of ¼-inch pipe, to one end of which is fastened the pointer. To the other end is fastened a short pointer *B* and handle *C*.

The short pointer works over a small dial similar to the large one on the front dial, and is used in setting the indicator; *D* is a tension washer to hold the pointer in place when set.

The hours from 1 to 12 are marked on a circular piece of sheet iron *E* which is fastened to a wooden hub and mounted on the pipe between the front sheet and the strip *A*. Through a hole *H*, in the front sheet, the hour figures can be seen, one at a time, the sheet being revolved to bring the various numbers into view.

The indicator is on the switchboard-gallery railing and is operated from the rear, as stated. It is quickly set and very easily seen from the engine-room floor below.

W. RUSSELL COOPER.

Indianapolis, Ind.

A New (?) Steam Gage

Under the heading announcing that subjects to be eligible for description in that department must be new or interesting, there appears in the department of POWER devoted to the description of power-plant machinery and appliances, in the issue of January 12, a description of an independent steam-gage movement. If there is anything new about this, the article fails entirely to bring it out. The movement mounted upon the base of the Bourdon spring and entirely disconnected with the casing has been a well known feature upon the market for a number of years and made by several makers. It is not at all evident why "jar and vibration do not affect the accuracy or sensitiveness" of such a gage as much as or more than that of the gage which is attached to the cage. In fact, I think that experience with this class of gage has shown it to be more susceptible to jar, although it is, of course, free from distortion due to relative movements of the case and the spring.

F. R. ALLEN.

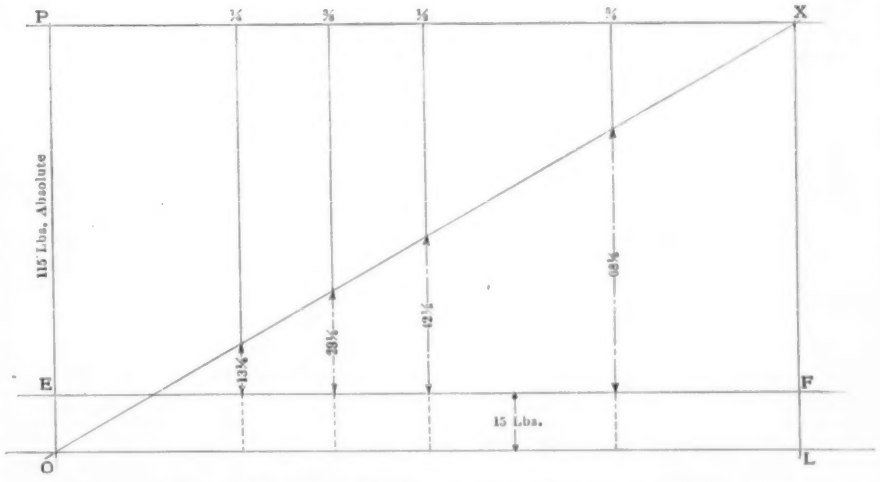
Chicago, Ill.

Approximation of Terminal Pressure

The graphical method of working problems appeals to many engineers who have a very marked dislike for figures and formulas. The accompanying sketch shows a graphical method of getting a close approximation of the terminal pressure in an engine with any initial pressure and point of cutoff.

The rectangle *O P X L* is laid out to represent in length *O L* the stroke of the engine (plus the percentage of clearance, if more accurate results are desired). In hight *O P* represents the absolute initial pressure. The atmospheric line *E F* is drawn parallel to the vacuum line *O L*, and at a distance above it equal to 14.7 or 15 pounds on the scale used, in this case a 50 scale.

Next, the diagonal *O X* is drawn, and from the line *P X* a vertical line is drawn from any point of the stroke at which it is desired to have cutoff take place. The distance between the diagonal and atmospheric lines measured with the given scale on the vertical lines will be found to be very close to the terminal pressure for that point of cutoff.



GRAPHICAL METHOD OF DETERMINING APPROXIMATION OF TERMINAL PRESSURE

In the sketch vertical lines are dropped at ¼, ⅜, ½ and ¾ stroke, and the distances between the arrow points indicate the respective terminal pressures for those points of cutoff.

In checking up the results mathematically consider the following example: Required terminal pressure in an engine with cutoff at ⅜ stroke, initial pressure 100 pounds gage, and steam ports of ample

size to keep the steam line well up. The absolute initial pressure will be 115 pounds, and as, theoretically, the pressure varies inversely as the volume, the terminal pressure will be in the neighborhood of ⅜ of 115 or 43⅛ pounds, or 28⅛ pounds gage. The actual pressure in an engine at the end of the stroke will be less than the computed result, owing to the exhaust valve being open.

By plotting out the expansion curves for the different points of cutoff, it will be found that the power derived from an engine does not increase in proportion to the length of cutoff by any means, i.e., if cutoff takes place at ¼ stroke, and it is increased to ¾ stroke, the power derived will not be three times as much, although three times as much steam is being used than with the former cutoff.

This goes to show how important it is to steam users to secure engines that will carry the average load at an economical point of cutoff.

J. A. CARRUTHERS.

Bankhead, Can.

Piston Repair

Not long ago one of the engines where I was employed gave signs of trouble inside the cylinder, and upon removing the head we found that a ½-inch hexagon nut had got into the cylinder on the crank end, between the piston and the cylinder head, and the nut of the cast-steel piston

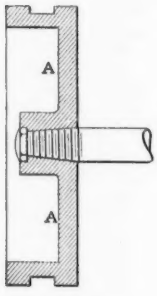


FIG. 1

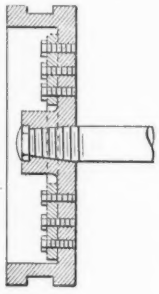


FIG. 2

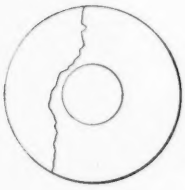


FIG. 3

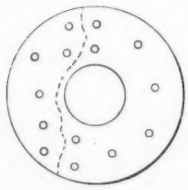


FIG. 4

of the type shown in Fig. 1 was cracked as shown in Fig. 2.

As we needed that particular engine the next morning, we at once got to work and procured a piece of ⅝-inch steel plate which was cut and drilled in the shape shown in Fig. 3, fitted into the recess (*A*, Fig. 1) of the piston, and securely fastened in place with machine bolts, as shown in Fig. 4, the plate being drilled with a clearance drill and the threads cut in the piston.

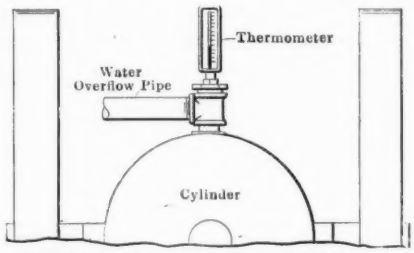
The engine was started the next morning and is running at the present time.

W. E. CHANDLER.

East Walpole, Mass.

Thermometer for Jacketing Water

One item gas engineers are prone to ignore is the amount of engine-jacketing water used. A scheme we adopted to decrease our water consumption was to



SHOWING LOCATION OF THERMOMETER

place thermometers on our outlet-water line just over the cylinders. Thus, we can watch the cylinder-water temperature and incidentally avoid turning too much water off.

We also placed a valve in the inlet pipe, having a pointer and index plate which, after experimenting, was marked at the proper point. We find that the engines work with the water temperature at about 140 degres Fahrenheit.

JAMES AYLWARD.

Elyria, O.

Hydrostatics

On page 1051 of the December 22 issue, Mr. Livingston presents the results of some original investigations of the laws of hydrostatics. It is hardly necessary to state that there is a flaw somewhere in the experiment, for it would be contrary to all laws of hydraulics if the check valve were placed in equilibrium by equal unit pressures on unequal areas. Does Mr. Livingston know that the check valve was in equilibrium? Does he know that it moved off its seat? It would seem more probable that either there was a leak through the casting or that the water leaked through the valve seat.

If Mr. Livingston desires to be exact in figuring the pressures on the two sides of the valve, he should take the pressure on the top of the disk equal to the head shown, 5 feet 8 inches, less the hight of the disk, remembering that the pressure on the area taken by the stem is that of the head on the top of the stem, and not that on the valve seat, this also being true of the pressure on the stem on the under side of the disk.

W. L. DURAND.

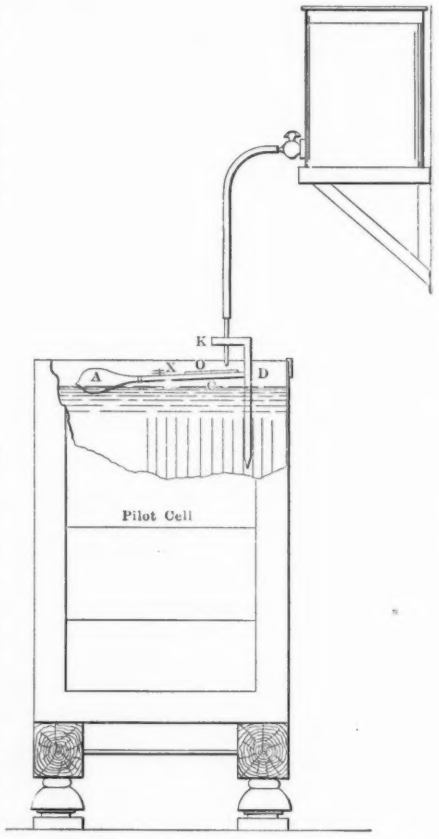
Brooklyn, N. Y.

Noncorrosive Float Valve

Difficulty has been experienced in attaining a standard hight of the electrolyte in pilot cells of storage-battery installations by corrosion of the movable joints of the float valve, causing sticking and failure to operate, the result being either a flooded cell, or no replacement for evaporation.

It is necessary with all pilot cells that the electrolyte be kept at a constant level so as not to deflect the specific gravity or the temperature readings. A sudden flooding of water would give a low reading by at least two points, for which no benefit of discharge or charge could be shown. By the condition of the pilot cell the standing of the entire battery is judged, both in charging and discharging. Therefore, the necessity of having a float valve which can be relied upon is readily seen.

The accompanying diagram gives an idea of how a noncorrosive float valve is constructed to meet all the requirements of a good cell filler. The materials used



CONSTRUCTION DETAILS OF FLOAT VALVE

are glass and hard and soft rubber. The glass float at *A* may be made out of an old 75-candlepower lamp, by first removing the metal base and sealing in the hard-rubber arm *C*. The counterbalance weights *X* are made of lead and placed as shown. The arm *C* moves on a hard-rubber pin inserted at *D*. The projection *K* is a hard-rubber holder for a glass tube, tapered at one end. A strip of soft

rubber is fastened at *O* to close the opening in the glass tube when the water raises the float *A*. The storage tank for the water is placed about 2 feet above the cell. This style of float valve has been operating two years successfully.

MALCOLM C. SAEGER.

New York City.

Pressure Required to Lift a Check Valve

Mr. Helm, in his academic discussion of Mr. Pearce's valve-lifting problem, on page 201 of last week's issue, correctly says that his method of figuring by the difference in area between the top of the valve and of the seven holes in the seat "assumes that the valve cover makes perfect contact with its seat." In other words, he assumes that there is no pressure acting between the valve and the seat, in which case the pressure holding it to its seat should be reckoned from absolute zero, and not from atmospheric pressure.

The pressure on top of the valve, then, would be 115 pounds per square inch, approximately, and the pressure required to lift the valve by acting on the 5.5 square inches of the seven 1-inch holes.

$$\frac{115 \times 1963 + 5}{5.5} = 410$$

pounds per square inch or 395 pounds, gage.

As a matter of fact, however, the valve does not make anything like a perfect contact with its seat. A pair of accurately ground surface plates, carefully manipulated, might approach that condition. The probability is that the pressure existing in the film of liquid under the valve is pretty nearly that of the fluid surrounding it, varying with the condition of the surfaces and the length of time they remain in contact.

J. H. MCCARTHY.

Bethlehem, Penn.

I read R. S. Livingston's letter in the December 22 issue, entitled, "Pressure on Both Sides of a Valve Disk," in which he describes a simple experiment performed by himself several years ago, which seems to show that results obtained in practice do not agree with theories and figures, or that theories and figures have no place in design, as they give results which are not at all borne out in practice.

If, however, the problem is looked into more carefully it will be found that they do agree, and that when taken together, each one serves its purpose in making clear the truth which is oftentimes hidden, and requires the coöperation of theory and experiment in order to know the hidden law and, knowing it, one is able to use it in practical everyday life for the benefit of mankind.

The apparatus as shown in the form of a diagrammatic sketch on page 1051 consists essentially of a check valve having a rubber-disk clapper $2\frac{9}{16}$ inches in diameter which closes a passage having a diameter of $2\frac{1}{16}$ inches. The upper or back side of the valve is acted on by a column of water 5 feet 8 inches high which gives a pressure *P* of

$$5.66 \times 0.434 = 2.456$$

pounds per square inch above the valve, which, acting on the area ($A = 5.157$ square inches) of the valve, gives a total force of

$$F = 2.456 \times 5.157 = 12.67$$

pounds tending to hold the valve on its seat.

This assumes that the valve disk or cover makes perfect contact with its seat, thus preventing the pressure of the fluid from acting on the under side of the clapper.

The area A_1 of the passage is 3.34 square inches, being 2.0625 inches in diameter; hence, the pressure p_1 per square inch on the front or under side of the valve necessary to cause equilibrium or to balance it will be

$$p_1 = 12.67 \div 3.34 = 3.8$$

pounds, which corresponds to a head of water of

$$3.8 \div 0.434 = 8.75$$

feet, or 105 inches above the valve seat, which means that the water will rise, in the ⅜-inch pipe, to a hight of

$$105 - 68 = 37$$

inches, plus a small amount required to overcome the weight of the valve seat, before the valve will open and the water will begin to overflow from the large pipe.

The results of Mr. Livingston's experiment, which he chooses to call "practice," showed that the water actually rose to only ¼ inch above the top of the large pipe, when rubber and metal were in contact, and to only ¾ inch above, when the valve seat was coated with white lead and oil. In other words, the experiment showed that theory and figures gave a pressure approximately 53.5 per cent. (average of the two cases) higher than was actually required in the particular case under consideration. Mr. Livingston's diagram shows a rubber clapper without any metal backing, which allowed the pressure from above to force the central portion of the disk downward, thus making it concave toward the back and convex toward the front, which resulted in greatly reducing the area of the seat, which is clearly shown by the result of the test.

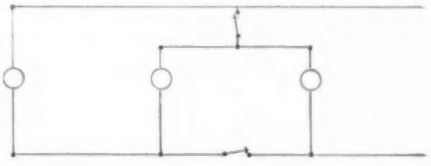
If Mr. Livingston or any other person desires to repeat the experiment and use every precaution to make sure that the valve seats properly, thus obtaining in practice the actual seat area which is assumed to obtain, and upon which the theoretical figures are based, he will find that theory and practice are not at variance, but are true friends, each one acting as an aid to the other.

F. C. HELMS.

Schenectady, N. Y.

Throwing Lamps in Series and in Parallel

On page 71 of the January 5 issue, E. J. Williams asks for a diagram showing connections to throw three lamps from



MR. FRENCH'S DIAGRAM

parallel to series and *vice versa*. The accompanying sketch shows a method using two single-pole, single-throw switches which, on closing, will put the lamps in parallel and on opening puts them in series.

JOHN FRENCH.

Brooklyn, N. Y.

The first of the two diagrams herewith submitted shows one method of meeting the requirements of Mr. Williams. With

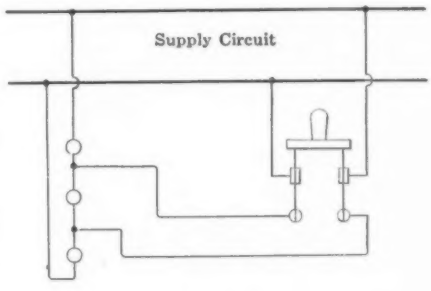


FIG. 1

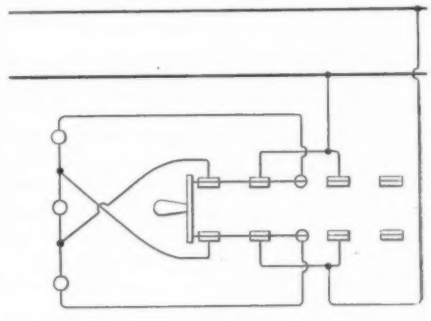


FIG. 2

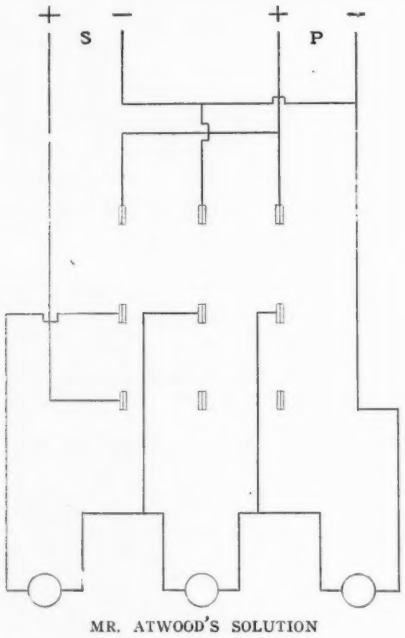
the double-pole switch closed, as represented, the three lamps will be connected in parallel to the supply circuit. With the switch open they will be in series. This method, however, would make it necessary to use another switch to extinguish the lamps. On this account the arrange-

ment indicated in Fig. 2 is preferable. A double-throw double-pole switch is used; closed to the left, as here represented, it will connect the lamps in parallel; closed to the right it will put them in circuit in series, and when open, the lamps will be entirely disconnected from the circuit.

GEORGE W. MALCOLM.

Brooklyn, N. Y.

Connect a triple-pole double-throw switch as shown in the accompanying diagram, in which *S* is the series circuit and *P* the parallel circuit. With the switch



MR. ATWOOD'S SOLUTION

in the lower position the lamps are in series; with it in the upper position the lamps are in parallel.

E. M. ATWOOD.

Lawrence, Mass.

Interesting Diagrams from a Dry Vacuum Pump

The accompanying diagrams were taken from a dry-vacuum pump driven by a cross-compound Corliss engine. Each engine piston rod extends through the head-end cylinder cover, and connects to an air-pump piston. The steam cylinders are 18 and 30 by 30 inches; the air cylinders, 40x30 inches. Four barometric condensers, of a total capacity of 10,000 horsepower, are connected by suitable air pipes to this pump, which was installed to take the place of a number of smaller dry-air pumps.

At the time these diagrams were taken, the outfit had been running quite a while, but had never been indicated. The governor was not in operation, the speed being controlled by throttling, as will be seen by an inspection of the "before adjusting" diagram, Fig. 1.

Through carelessness on the part of the erector, one of the low-pressure exhaust valves had been put in upside down. The governor was connected, and a few changes in the valve gear resulted in the steam distribution shown "after adjusting," Fig. 2.

The valves of the air cylinders are of the Corliss type, positively driven, and as

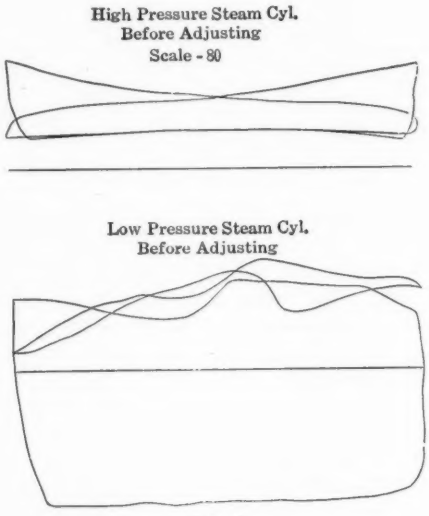


FIG. 1

set by the erecting engineer gave diagrams as shown by Fig. 3. By changing the eccentrics driving these valves and making some alterations in the lengths of the valve rods, the diagrams, "after adjusting," Fig. 4, were obtained.

This air pump is provided with a rotary valve which, at the end of each stroke, opens a passage between the two ends of the cylinder. The air in the clearance space, at a little more than atmospheric pressure, is then permitted to expand into

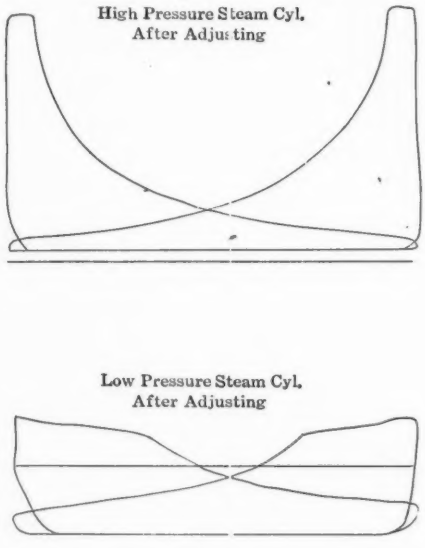


FIG. 2

the other end, where it may be forced out on the next stroke. The point in the stroke where this valve closes is clearly indicated at *A*, Fig. 4.

Although every precaution is taken to separate the air from the water before it leaves the condensers, a great deal of trouble is experienced with water entering the air-pump cylinders. The air coming from the condensers is passed through a baffle-plate separating arrangement and, before entering the pump, it is passed through a large drum, which is intended to act as a separator for any water that

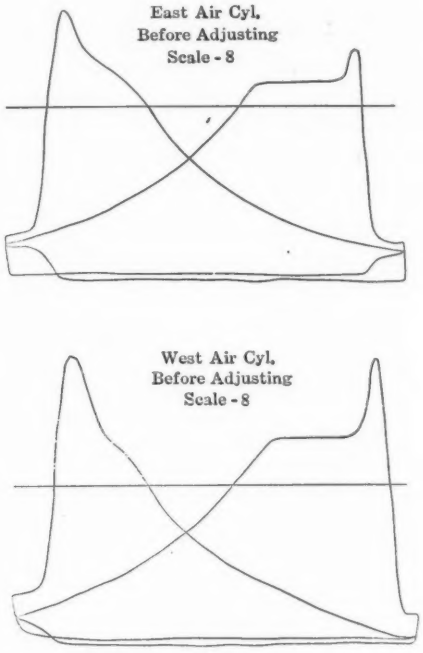


FIG. 3

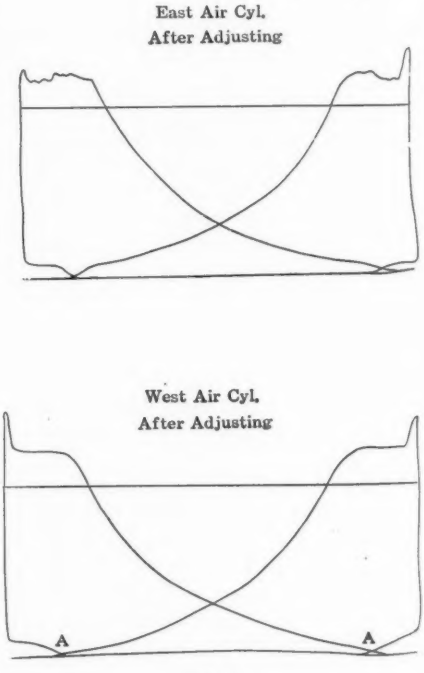


FIG. 4

may be carried over from the condensers. Yet water is being continually forced out of the relief valves, and it is necessary to run quite slowly to avoid danger of wrecking the pump.

A. L. WESTCOTT.

Columbia, Mo.

Repairing a Valve Rod Stuffing Box

The accompanying illustrations show how a quick repair was made to the valve-rod stuffing box on an indirect piston-valve engine. The exhaust pipe filled with condensation one night and the assistant started up the next morning without opening the drain on the pipe, which resulted in a broken gland at *A*, Fig. 1.

We removed the cap screws and replaced them with long studs, as shown in Fig. 2. The brass gland was held in place with a strip of wood, with nuts as washers instead of the screwed gland. There was only room enough for two turns of soft packing, yet it held so well that we replaced the wood strip with a cast-iron gland of the ordinary pattern, and drilled two extra holes in the head for gland studs.

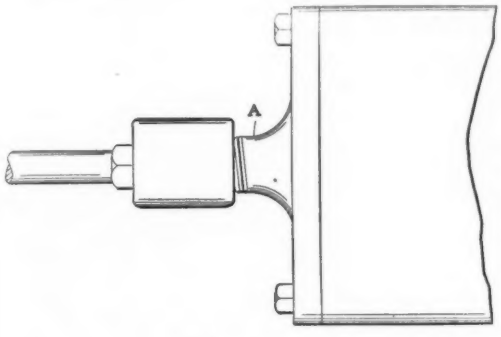


FIG. 1

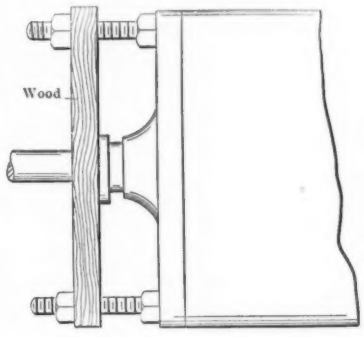


FIG. 2

GEORGE C. JAMESON.

Buffalo, N. Y.

Power Consumed in Centrifugal Pumps

I have noted frequent discussion in reference to the power consumed in centrifugal pumps when working under heads sufficient to prevent discharge, and under a closed discharge, and beg to offer some practical experience I have had

Last year I had from one to twenty-five pumps, of all capacities, under my care, most of them working a 24-hour shift, and operated by an automatic device controlled by the rise and fall of the water in the building excavations, etc., which were being pumped.

Before the present automatic device was perfected various devices were used to control the discharge according to the supply, which varied greatly with tides, etc.

It may sound peculiar, but of the three methods where frequent stopping and starting were generally necessary, it was found most economical to allow the motor to run continually and close the discharge by a float, in preference to starting and stopping under the usual head, or by use of a sliding resistance in series with the motor. The rank of the three methods in economy was as follows: Closing the discharge entirely; sliding resistance or variation of speed, and intermittent starting and stopping.

I noted that in pumps where either the suction or discharge was choked near the pump the only power required was that consumed in the friction of the water on the side walls and the slippage of the vanes, which in turn was converted into heat. Or I judged this was all that was required, as the current consumption was but little above the motor consumption running light. This was not the case where the pump supported a high column of water but did not discharge, for the same power was required as when discharging under about seven-eighths of the length of the column, with the same speed.

A specific case was that of a 2-inch pump working under an 85-foot head, with 7 feet for the suction. I had some difficulty in making it keep primed when running, for when at rest the weight of the column forced the packing out. In order to watch the action of the gland a vacuum gage was put on the suction, and a gate valve on the discharge pipe. When the gate valve was closed, close to the pump, the current consumption of the motor was reduced and the vacuum dropped to from 8 to 10 inches, or just sufficient to support the column of water in the suction pipe, and the pump soon became very hot. If the speed was insufficient to discharge in cases where the gate valve was open, the motor took about the same power as when discharging fully under seven-eighths of the head. I took many readings and obtained much data at the time, but unfortunately they were destroyed in a fire.

I came to the following conclusions: Pumps working under a closed discharge require only sufficient power to overcome the friction of water in the pump, support the column in the suction and overcome the loss in the bearings.

Pumps working against a column of water without discharge required the power necessary to overcome the friction of the water in the pump, and bearings, to support the column of water in the suction and discharge.

Pumps when working under full discharge followed very closely the law: *Power required is proportional to the square of the speed and directly to the head.* I also found that the make of pump we used was most economical when discharging at a velocity equal to eight times the square root of the head.

E. H. ESCHER.

Berkeley, Cal.

Effect of Scale in Boilers

F. Hilton Williams, in his letter in the December 8 issue, asks for information.

He says that many tell us that $\frac{1}{16}$ inch of scale will cause a loss of from 12 to 15 per cent. in fuel, depending on the character of the scale. While this is true to a certain extent, it is a difficult proposition to determine to just what extent the efficiency of a boiler is lowered by a deposit of scale on the plates and tubes.

There are a number of things to be taken into consideration in calculating the effect of scale in boilers, not only the character of the scale, but the thickness as well, and also the nonconductivity and the difference of temperature between the inside and outside surfaces of the boiler shell.

I have seen scale not over $\frac{1}{16}$ inch in thickness in boilers that, by actual test, showed a drop in efficiency of over 20 per cent. On the other hand, I have seen $\frac{7}{8}$ inch of scale on the boiler shell, and the ends of the tubes practically matted together, with the efficiency of the boiler impaired so little that it was hardly susceptible of calculation.

I have frequently seen carbonate of lime $\frac{1}{2}$ inch in thickness, with very little injury done to the boiler and with very slight loss in efficiency. Alone it seldom produces a hard scale, but more often has a tendency to collect in large porous lumps or masses, in which state it is more liable to produce overheating, and consequent burning of the sheets where so collected, than to impair the efficiency of the boiler.

This scale can usually be washed out very thoroughly with a hose, or by frequent blowing down of the boiler, unless there had been the presence of a lot of iron in the feed water, in which case the carbonate of lime will sometimes combine with it and produce a scale of varying degrees of hardness, depending on the per cent. of iron present. It is very seldom that carbonate of lime and oxides of iron are found in the same water, in great quantities.

Entirely unlike carbonate of lime, the sulphate, or gypsum has a hard, flint-like resemblance, is nonporous, a nonconductor and one of the most detrimental of mineral substances. A very thin layer of this deposit is very apt to bring about serious injury to the boiler, unless treated very extensively with soda ash. Tannin

is also very effective in precipitating sulphate of lime deposits, as is also caustic soda, but the simple soda ash is usually conceded to be about the best solvent for this form of scale.

Among the other common enemies of the boiler might be mentioned the carbonates and chlorides of magnesia, oxide of magnesia, silica and clay substances. Of these latter the chloride of magnesia is the most objectionable. At a temperature of 290 or 295 degrees Fahrenheit it will begin to give up free hydrochloric acid, due to decomposition, and as the temperature increases to near 298 degrees this liberated hydrochloric acid combines with the oxide of iron, continually forming on the surface of the boiler shell, with the result that the plates are corroded and pitted.

Deposits in boilers due to grease and oils in the feed water are also sources of great annoyance and danger, as a very thin film of this substance, while soft and apparently porous, forms a most perfect nonconductor, prevents the water from coming in contact with the plates, and is almost certain to bring about overheated sheets and tubes, with the attendant disastrous consequences.

Mr. Williams further asks: "If the loss with $\frac{1}{16}$ inch of scale is so great, it would be interesting to know where this heat goes to. Does the boiler setting absorb more heat than it would otherwise, or is the loss entirely accounted for by a rise in the temperature of the escaping gases?" To the first I would reply, not at all; to the latter, not entirely, but possibly to some extent.

We all know that the degree of heat transmitted from the furnace to the water in the boiler depends upon the conductivity of the intervening metal, and it is also known that the water cannot be heated to a higher temperature than is equal to a corresponding pressure of the steam.

Let us consider steam at 100 pounds, absolute pressure, the corresponding temperature of which is 327.9 degrees. It is impossible to increase the temperature of the water above this without increasing the steam pressure.

With a boiler plate free of scale, with the water in perfect contact with it, it is impossible to heat the plates much higher than the temperature of the water, or 327.9 degrees at 100 pounds pressure, a temperature which any plate will stand without any injury whatever.

Suppose the plates are coated with a thick deposit of nonconducting material, thoroughly insulating the water from them, then it is evident that the temperature on the different sides of the plates cannot equalize as formerly, one counteracting the other, thus permitting the plate to reach a higher temperature than the water in the boiler and the consequent overheating of the plate until it may reach a cherry red, depending upon the thickness, quality and nonconducting properties of the scale. This, then, explains where the heat goes, not in the brick setting of the boiler, nor all in the escaping gases, but the greater part is absorbed by the plates, which accounts for their rise in temperature. If the plates did not take up or absorb what the water loses, there would never be any danger of overheating due to the presence of scale in the boiler.

J. L. Bradshaw.

Memphis, Tenn.

Low Compression Saves Coal

I used to be ashamed to send my indicator diagrams for engineers to criticize, but when I saw a set of diagrams from a cross-compound engine which M. E. Copley praises as evidence of the only way to set valves to save coal, I thought they resembled a pair of Chinaman's shoes

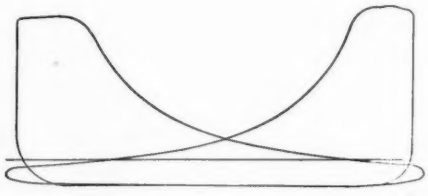


FIG. 1

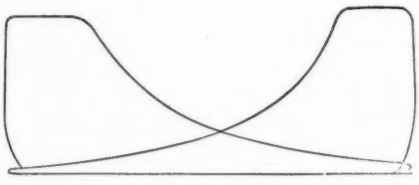


FIG. 2

after having been worn over the Texas border on the way to Uncle Sam.

Mr. Copley says that slight compression saves coal. Perhaps it does, but the valve setting on his compound engines does not seem to me to be the best for the coal pile. Readers who know about indicator diagrams can see that the exhaust valves do not get open until the piston has traveled over half stroke. Steam on the one side of the piston is pushing the piston ahead and the piston is pushing the steam out through the exhaust port.

What good is a condenser to an engine with such valve setting? If an engineer wants to get the benefit of the condenser he should set the valves so the exhaust will open before the piston reaches the end of the stroke and close as late as possible.

I inclose a set of diagrams from an old Corliss engine in service since 1872. In summer I run condensing, as the diagram, Fig. 1, shows. With this valve setting the engine runs on $2\frac{6}{10}$ pounds of coal per horsepower-hour. The diagram, Fig. 2, shows the valve setting for winter, as we use the exhaust steam for heating with the Paul system.

M. E. Cunningham.

Waterbury, Conn.

Grease Lubrication of Governor Pins

I use grease successfully in the lubrication of the governor pins of four Westinghouse compound noncondensing engines under my charge. This I consider a difficult lubricating proposition, as the weight on the bearing and journal is heavy and the motion, instead of being one of continuous rotation, is an oscillation through a short arc, only. The engines are direct-connected to 114-volt direct-current generators, delivering current for forming and charging storage batteries in the process of manufacture, and for laboratory purposes. For this work the requirements as to constancy of voltage are very exacting, and the matter of close speed regulation is therefore of unusual importance.

The plant consists of two 18 and 30 by 16-inch 350-horsepower engines, each direct-connected to a 2000-ampere eight-pole generator, and three 12 and 20 by 12-inch 150-horsepower engines, each direct-connected to an 800-ampere six-pole generator. These engines run at 150 pounds steam pressure and are operated for thirteen consecutive shifts through the week—two shifts each 24 hours for six days in the week, Tuesday to Sunday, inclusive, and one shift on Monday.

The governor pin of one of the larger units is lubricated by oil, from a regular Westinghouse center oiler, which consumes 2½ to 3 gallons of oil per week of thirteen shifts. The governor pins of the other 350 horsepower engine and the three 150-horsepower engines are lubricated with an A No. 1 grease, and consume 4 to 6 ounces of lubricant per week of thirteen shifts.

The lubrication by grease is accomplished as follows: The governor mechanism is of the Westinghouse high-speed engine type. The governor pin, which is 3½ inches in diameter and 12 inches long on the larger engines and 2x12 on the smaller, runs in a brass bushing which is carried on a radial extension of the flywheel hub. Fixed to one end of this pin is the lever carrying at its ends the two governor weights, aggregating 1000 pounds. In the operation of the governor, the pin oscillates through a maximum arc of about ¾ inch, between light load and full load on the engine. The movement of the pin in the bushing is therefore relatively small. At the same time the importance of safe and effective lubrication is very great. Any least liability of "sticking" would condemn the lubricant causing it, for it would result in impairment of the governor action, which would not be

tolerated in these engines, operating under the stated exacting conditions, to say nothing of the risk of racing, with its attendant danger of bursting flywheels.

The grease is applied by means of two ordinary hand-feed spring-tension cups, set in ½-inch tapped holes in the bushing. These holes meet a half-round groove of ⅛-inch radius scored on the inside or bearing surface of the bushing, and running to within ⅜ inch of the ends. This (top) groove is thus fed direct by the two grease cups; and two similar horizontal grooves, spaced at 60 degrees from the top groove, are fed from the latter by several diagonal grooves, which serve also further to distribute the lubricant over the journal.

This arrangement answers well and for nine years has proved the effectiveness of grease for governor-pin lubrication. The cups are filled once a week, and the lubricant is not fed into the bearing by screwing down the plungers of the cup, but is allowed to flow naturally. The cups, once filled, require no further attention during the thirteen consecutive shifts and there is neither waste nor lack of lubricant.

Although this and other experience going to show the success of grease lubrication and its economy, as compared with oil, make me an advocate of grease as a lubricant, I am ready to concede that there are places where oil must be used. Thus, in these same Westinghouse engines the lubrication of the main eccentric rod and its appurtenances is effected by oil fed at the top of the rod and shaken down by the oscillation to the bearing surfaces below. Here, of course, grease would not serve. But aside from such special cases, in the writer's opinion, since the lubrication of any moving part of a machine is really a *greasing*, it is better to use good grease to begin with. The value of oil as a lubricant resides in its permanent greasiness, while its other qualities tend to waste and to mess.

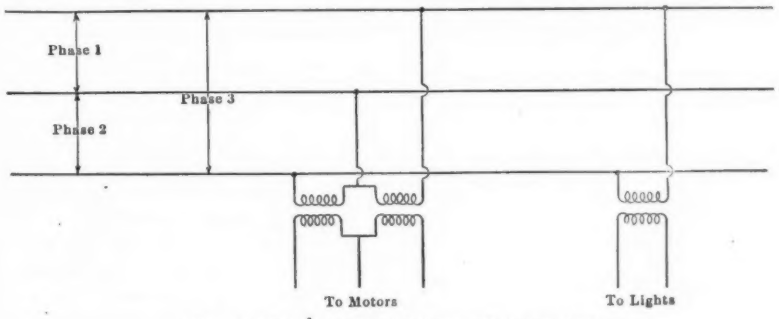
In conclusion, I wish to state that the engine room in which grease is used for this work, as described, is an unusually hot one, the temperature registering 150 degrees Fahrenheit for seven months in the year.

FRANK MELLOR,
Chief Engineer, Electric Storage Battery Company.

Philadelphia, Penn.

Transformer Connections

I submit the accompanying diagram and the following for criticism: Two transformers are connected in open delta on a three-phase line supplying current to three-phase induction motors, and a single-phase transformer is connected to one leg for lighting. If the power transformers are connected to phases 1 and 2 should not the lighting transformer be connected to phase 3? How will this affect the regulation of the system? The motors are used in the daytime and the lights are then turned off; at night the lights are on and the motors are out of service.



MR. CARROLL'S TRANSFORMER CONNECTIONS

R. S. CARROLL.

Portland, Ore.

Reversed Polarity

The trouble caused by the reversing of the polarity of one of the generators operating a three-wire system, which Mr. Young gave an interesting account of in the number of December 22, could be caused in a number of different ways. In this case, however, it was probably due to weak residual magnetism, allowing the machine to build up in the reverse direction. This is often noticeable in generators having a magnetic circuit of very soft iron. I have also known of the polarity being reversed by a sharp, heavy shock on or rear the machine when repairs are going on. A momentary current from some outside source flowing through the field coils in the wrong direction while the machine is at rest often causes the same result.

The reason that the outside 220-volt wires gave no indication of voltage was because they were of the same polarity, the central or neutral wire then carrying the current formerly carried by the two outside wires, instead of the small balancing current which it is supposed to carry. If a load had been put on with this arrangement it would have been practically impossible to keep the voltage normal, owing to the excessive drop in the neutral wire.

When Mr. Young reversed the shunt-field connections, he made a bad matter worse, owing to the fact that as the machine began to generate it would cause the residual magnetism to become still weaker. After the brush connections had been reversed the current flowing in the series fields with a load would naturally tend to lower the magnetic flux through the armature, instead of increasing it, thereby causing the drop in potential as the load came on. If the brush connections had been changed in the first place no other alteration would have been needed.

It very often happens that connections cannot be easily changed, or if changed, would materially injure the appearance of the apparatus. In such cases, and in fact nearly every case where direct current can be obtained at the proper voltage, the writer favors magnetizing the fields from this outside source, so as to cause the polarity to stand as it should for proper operation. It is a good idea to have a pilot light connected across the two outside 220-volt wires and located either on the switchboard or, better still, near the generator set, where the operator can see at once when starting whether or not the polarity is reversed. He could then immediately remedy the trouble and not keep customers waiting for light or motor power.

FRANK A. BYLES.

Bennington, N. H.

Card Indexing

Having preserved my copies of POWER, as well as those of several other technical magazines, I began some time ago to look for some method of indexing the matter contained in them.

The separate issues were punched with five holes, about ½ inch from the back, and dividing the year's issues into two volumes; a dark paper cover was made for each, after which a shoe lace was run through the holes, binding all tightly together.

For the indexing, a form of card index is prepared. Mine is divided into main heads, such as Steam, Electricity, Hydraulics, Gas, etc. Under these heads come subdivisions, as Types (under which are listed the articles describing particular installations in different parts of the country), Operating, Repairing, etc.

These main and subdivisions may be arranged in any way the user thinks best, but I have found the foregoing very convenient. One need not have a separate card for every article by any means, as all articles bearing on one particular subject may be listed on one card, together with notes giving a short outline of the article in question. This last feature is where the card index surpasses the regular index furnished, as it is sometimes difficult to tell from the title of an article just what may be contained in it, but a few notes on the card will show this at a glance.

WILLIAM H. RHODES.

Berkeley, Cal.

Water Evaporated per Pound of Coal

Under the above caption appears a very interesting letter by E. E. Edwards, on page 1052 of the December 22 number. If Mr. Edwards will make a test of his coal he will very likely find that it is much higher in heating value than his boiler trial indicated, and that the trouble is more apt to be in the boiler and furnace, in the form of air leaks, poor circulation and faulty boiler setting.

If he would take a sample of his flue gases and have them analyzed he would doubtless be surprised at the results.

C. T. McKnight.

San Antonio, Tex.

Cement Roofing

In many cases cheap roof construction is used, which in the end proves very expensive. I caused to be placed on a roof about 30 squares of corrugated iron that did not last quite a year. Before it had become entirely unserviceable, I repaired it with a permanent, and what I consider the best, roofing that can be used. I stretched over the entire roof a 2-inch mesh poultry wire, and with a trowel spread cement about ¾ inch thick; by troweling the cement when in a plastic condition it entirely enveloped the wire.

No crack nor check appears in the roof, which has 4x12-foot spans, although the iron has nearly disappeared. In testing this roof, several men at a time have walked over it, and it showed no weakness. It is fireproof, and will practically last for all time. But the most interesting fact about this cement roof is the cost, about $2 per square, buying the wire and cement at retail. I used three parts sand and two parts cement.

Arthur Seymour.

Linton, Ind.

Steam Gages and Indicator Springs

One night while indicating our engines we noticed an unusual drop in pressure between the boilers and engines. The gage at the boilers showed 100 pounds pressure, while the indicator on No. 1 engine showed an initial pressure of 74 pounds, a difference of 26 pounds. No. 2 indicator on No. 2 engine showed a drop of 20 pounds, although 20 feet farther from the boilers than engine No. 1. There is no apparent reason for such a drop, as the pipes are short and of ample size and have straightway valves.

To locate the trouble we put No. 1 indicator on one of the gage connections to the boilers. With the same spring, and the same gage pressure, 100 pounds, the indicator showed 82 pounds, a difference of 18 pounds. We then tried No. 2 indicator in the same way. This gave us 90 pounds. A 50 spring was used in both cases. We next tried No. 1 indicator with a No. 60 spring and got a reading of 90 pounds, the gage still showing 100 pounds pressure. The last two readings being alike, the No. 50 spring in No. 1 indicator must be 8 pounds heavy, and the steam gage 10 pounds light, if the two springs are correct.

The steam gage was tested six months ago. The indicator springs are also practically new, and of a well-known make. The difference in this case is in favor of the boilers, but in many others it may be otherwise.

The question is, how long may we expect springs to retain their accuracy and steam gages to remain correct?

W. J. Wilkinson.

North Bay, Ont.

Development of the High Speed Engine

I think Frank H. Ball, in his lecture before the Modern Science Club, as quoted in the January 19 number, is "off" in some of his historical statements. He credits Mr. Porter as having shown a high-speed engine at the Paris exposition in 1875. There was no 1875 Paris exposition. Mr. Porter exhibited a high-speed engine in the London exhibition in 1862, which, though not as high-speed as his later ones, was fast enough to astound the English builders, and at the Paris exhibition he exhibited three, one, I think, about 12x24-inch, which ran at 200 or 250 revolutions per minute, and a 6x12-inch engine which he thought to run at 1000 revolutions per minute, if I remember correctly, and which he did run, I believe, at 600 or 700 revolutions per minute. The third engine was a complete 6x12-inch engine with one-quarter of the cylinder cut out to show the construction and action of the valves and valve motion.

As to the Armington & Sims people building the first single-valve shaft governor, I do not think they started in business until the early eighties; while the first Straight-line engine was built in 1871, and the second built at Cornell in 1875, and exhibited at the Centennial in 1876.

J. C. Hoadley had built shaft-governor single-valve portable engines before, but they were not, as far as I know, introduced in regular horizontal engines before Mr. Hoadley went out of business.

Though Mr. Sims was a Hoadley man, when the Armstrong & Sims engine came out it could not be said to be a continuation of the Hoadley design, being different in all essential features.

John E. Sweet.

Syracuse, N. Y.

Culm and Coal Dust for Fuel

In Mr. Jeter's article on "Culm and Coal Dust for Fuel," published recently, there are several statements that are not borne out by the experience of some us who have experimented with briquets. He states that a ton of briquets made from anthracite dust equals three tons of best anthracite, as proved by a number of tests.

The best anthracite to my knowledge comes from Colorado. According to Kent, the approximate analysis of the best quality of Gunnison county coal is as follows: Moisture, 2 per cent.; volatile matter, 2.5 per cent.; fixed carbon, 91.9 per cent., and ash, 3.6 per cent. This would give a heating value of 14,100 B.t.u. per pound of coal. According to Mr. Jeter's figures, a ton of briquets would develop 42,300 B.t.u., to attain which would require the consumption of one-half hydrogen by weight, or by volumes 12 parts hydrogen to one of carbon.

The first briquets of my acquaintance were made from Carterville (Ill.) washed slack. There was little difference in the burning qualities between them and the egg coal from the same district. The smoke was no greater and the ash slightly less. In my young days I believed the nearer the boiler was to the fire, the better it would steam. This is undoubtedly true with anthracite or wood, but it is a great mistake with soft coal, and the lower the ratio between the volatile matter and fixed carbon, the farther the grate should be from the shell of the boiler. My last venture was to set the grates 48 inches from the boiler (for Belleville, Ill., screenings), and my next one will be 54 or 60 inches. In the last case the ratio of volatile matter to fixed carbon was about 1:1 and the amount of soot generated was quite small.

I believe that anthracite culm washed and briqueted can be made the ideal fuel. The ash-forming ingredients and sulphur, if present, can be removed in great part by washing and a pitch binder will furnish enough hydrocarbons that the resulting briquets will approach the semi-bituminous coals of Maryland, West Virginia and Arkansas in composition and heating qualities. As anthracite does not usually exceed 10 per cent. in ash, and pitch has none, the briquets should be an improvement on the general run of commercial coal in that respect. They will need ample room for combustion of the volatile matter and must be fired as bituminous coal is fired, and when properly handled, produce no more soot or smoke than George's creek or Pocahontas coals.

LeRoy Baker.

St. Louis, Mo.

A uniform boiler-construction law for the Dominion of Canada is being agitated, with a bright prospect of its adoption.

Some Useful Lessons of Limewater

Various Practical Experiments for the Boiler Room, Which Will Add to the Furnaceman's Knowledge and Increase His Efficiency

BY CHARLES S. PALMER

Mr. Furnaceman, this is for you. You are sitting on that barrel of lime that has been rolled into your boiler room, waiting for the masons to put on that addition to the mill. But you are not thinking of the mill; what is bothering you is the trouble with the water, and that scale that will get onto the boiler tubes. The water looks all right; and there is the heater in the corner which does take out some of the stuff that makes the scale; while up on your shelf are those samples of boiler compounds that the salesmen left for you to try; and sometimes they work, and just as often they don't, and you are at your wit's end. Now, you may not believe it, but you can do a bit of study and thinking right down here in this dusty place—thinking and doing, too—that will help you to get onto your job a little better. Try it; it will not do any harm, and it may put you on your feet as you have never stood before. It may help you to understand your work better, and no man is doing right by himself or his business unless he knows how to do the thinking that goes along with his special work. Some of the best and most skilful workmen wear plain clothes, and the hints that will be contained in these articles may put a dollar or two in your pocket.

Do you know that you are *sitting* on your opportunity? Do you realize that that barrel of lime has some secrets that it will pay *you* to know about? There is a whole college course of practical chemistry right under you, waiting only for you to take hold of it and use it in your daily work and thinking. It isn't merely a matter of muscle that makes the difference between a low-paid and a high-paid man. There isn't anyone who is holding you back, except one man, and he certainly has got it in for you. That man is the chap that walks under *your* hat. Did you ever think of that? Then take a brace—a good hard brace—and let us help you to do some commonsense study right down here in the boiler room. It can't hurt, and ten to one it will show you something that you can use to help the man who pays your wages, and to help you to command more pay. So, take right hold, here and now, and tell us if we talk over your head, for we want you to learn something to *your* advantage. Once you get started, you'll find it easy.

You may get the apparatus and chemicals which you will want in these self-help lessons from your druggist; and for every dollar you put out now on this furnace-room laboratory, to use right down by your boiler, you will get a return some time that will pay you back ten to one; not only in the mental satisfaction of knowing your work better, not only for your being able to hold your head higher from knowing what others know and are learning with you, but certainly, for the better position and pay that you

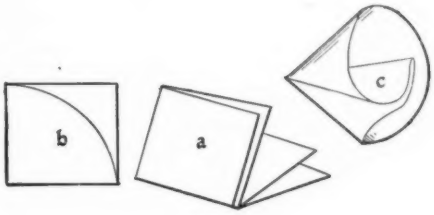


FIG. 1

can command in the long run, and perhaps in the short run. If it should happen that your druggist cannot supply you, the materials may be obtained from Eimer & Amend, 205 Third avenue, New York City, or E. H. Sargent & Co., 143 and 145 Lake street, Chicago, Ill. The former will charge $3 for them all packed ready to ship, and the latter will deliver them to the nearest railroad station for $3.50.

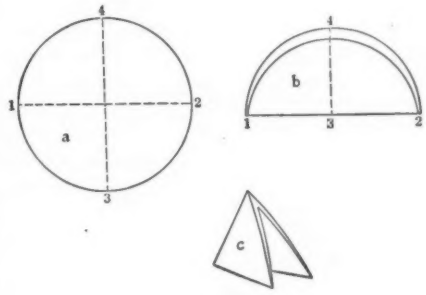


FIG. 2

Following is the list of materials required:

1 plain-glass 4-inch funnel, with long stem.
1 corrugated- or grooved-glass 4-inch funnel.
50 sheets of filter paper, 7x½ inches; or several uncut sheets, as preferred.
3 straight glass tubes, 1 foot long and, say, ¼ inch in diameter.
3 glass tubes bent at right angles, same size as the straight tubes, one with the arms of equal length, one with one arm 3 inches long and one with one arm 5 inches long.
3 glass stirring rods, 3/16 or ¼ inch in diameter.
1 foot of rubber tubing to fit the glass tubes.
2 four-ounce glass flasks, with plain corks.
1 four-ounce glass beaker.
1 six-ounce glass beaker.
1 round 3/16-inch file, to smooth the holes in the corks.
12 plain-glass test tubes.
2 sheets of litmus paper, one red and one blue.
1 four-ounce bottle of hydrochloric acid.
1 four-ounce bottle of nitric acid.
1 four-ounce bottle of sulphuric acid.
1 four-ounce bottle of ammonia.
1 four-ounce bottle of sodium hydroxide.
1 four-ounce bottle of sodium carbonate.
¼ pound of potassium chlorate.
¼ pound of black oxide of manganese.
1 two-ounce bottle of solution of barium nitrate.

A box of gummed labels is useful, but homemade labels will answer.

The First Lesson

Take a piece of fresh lime the size of an English walnut and break it into any clean bottle holding about one-half pint. Nearly fill the bottle with water as pure as can be got. Of course, distilled water is best; but rain water, melted snow, condensed water from waste steam, etc., will do very well. Close the bottle with a clean, common cork, shake well and let it stand a few minutes. Next, procure a clean funnel. One with channels and grooves down the inside of the conical part, and called a "corrugated funnel," will filter faster than a plain one. The funnel should be of glass, about 3 or 4 inches across the mouth; and if the stem is 5 or 6 inches long, the suction of filtered liquid in the stem will actually help to pull the liquid through faster than it will in a funnel with a short stem.

As for the filter paper, common "qualitative" paper will do. It should be white, and porous; not like the slow, gray, eight-day stuff that some druggists try to palm off on the beginner. You can buy it cut in round shapes, and of various sizes, or in large sheets, to be cut down to size as wanted. A piece 7 or 7½ inches in diameter will fold down to a cone to fit the funnel, being about 3½ inches across the top. If the filter paper comes

in sheets, fold, crease and cut it as shown in Fig. 1. Take a piece about 7½ inches square, fold it twice, as shown at *a*, lay it down and trace a curve *from the closed corner* of the paper, as at *b*, and cut this folded paper along the curve; when you open it, it will look something like *c*. Or, if you get the filter paper in packages of "cut" paper, you will fold it as shown in

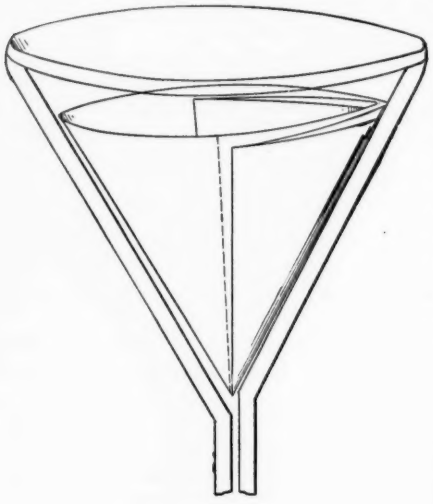


FIG. 3

Fig. 2. Referring to *a*, first fold it across the line *1-2*, to halve it, and then, to quarter it, fold along the line *3-4*, folding the point *1* over and down on point *2*; then when you open it, it will look much like *c*, Figs. 1 and 2.

Next, fit this piece of quarter-folded filter paper down into a funnel about 4 inches across, so the point or apex of the cone of the paper fits nicely down into the opening of the stem of the funnel. You will notice, when you have done this, that on one side there is only one thickness of paper, while on the other side there are three thicknesses. That is all right; it will do its work. You will also note that when the paper is in the funnel, closely fitting it, it will look like Fig. 3. You will further note that to have the conical cup of filter paper closed on the under side, where it fits the funnel, the paper has to turn back on itself twice. All this may seem simple to the man who knows all about it, but you will have to use your wits to get some of these simple things right. You can do it, however. A sketch of the corrugated funnel, with its stem in a bottle, is shown in Fig. 4.

When the filter paper has been fitted into the funnel, which has been set with its stem in the neck of a clean bottle, as stated, dampen the paper with a few drops of water, to "break its back;" otherwise, it will spring back and crawl out of the funnel, even if the funnel is standing upright.

The next step is to open the bottle of limewater, which may be quite milky. Don't lay the cork down anywhere, but hold it between the third and fourth fingers of the right hand, with the palm upward. In fact, that will be found to be the best way to take the cork out of the bottle. The cork will not get soiled, then, and is ready to go back in place instantly. Or, you may hold the cork in your left hand and use it to direct the stream of liquid as it is poured into the filter paper in the funnel. If the cork is held close to the mouth of the bottle, as it is tipped with care to pour, the stream will follow down the side of the cork.

We are to filter the milky limewater through the funnel into a second clean bottle, say half a pint, or even a pint or more; for you will use this limewater on a number of different occasions. If the stem of the funnel fits too tightly into the mouth of the second bottle, slip a bent match or wooden toothpick between the funnel stem and the mouth of the second bottle, to leave a crack for the air to escape through as the filtered limewater runs in (as shown in Fig. 4).

How to Clean a Bottle

To digress for a moment, you may as well learn a trick for cleaning bottles. Tear up a small piece of common paper (any kind, newspaper will do), say a piece 5 inches square, into little bits the size of a dime or smaller. Put these paper bits, with a little soapy water, in the bottle and shake well, and with a motion to make the wash water swing around the inside of the bottle. The edges of the paper cut off the dirt from the smooth surface of the glass, and when the bottle is rinsed several times it is clean, cleaner than washing with shot will make it, as a rule.

To go back: Don't fill the filter paper in the funnel higher than to within about ½ inch from the top, then there will be no danger of the milky water creeping up above the paper, running down the side between the paper and glass and thus get through without going *through* the paper. All this and a dozen other points you will learn by trying; it is really very simple, and anyone can do this in a kitchen or boiler room. Filter enough into the second bottle of water so that it will be full, for it will be found that the air will act on this filtered limewater, and if the bottle is full to start with less air can get in below the cork.

It takes a few minutes to get this bottle of filtered limewater ready for use. When it is ready you will label it with one of the adhesive labels which came with your outfit; or, if you haven't that, get your wife to make you some flour paste by cooking a teaspoonful of common wheat flour in hot water. You should write "Limewater" on the label. If you know how to do all this, why, just skip the reading up to this point; but you will have this first reagent on hand; and you had better fill the bottle of lime again with water, shake and cork it, laying it aside ready to filter more limewater as needed.

This bottle of filtered limewater is the *door* leading to a whole lot of useful facts and self-instruction; indeed, it is a laboratory by itself. Look at it. It is as clear as water, and you may doubt whether it is anything more than common water. But just *taste* it; that is test No. 1. It is perfectly safe to taste it, for you may have given some of it to your baby at home, with its milk. Before you get through with this, you will see why you gave it to the baby. The limewater tastes slightly bitter-sweet, and it has also what is called an "alkaline" taste, a taste that you will want to learn.

Pour some of the limewater into a clean tumbler or one of the little thin-glass cups, "beakers" they are called. Breathe down into this limewater strongly; or, better still, blow through the limewater your good, sound breath, through a clean pipe stem, a straw, or one of the pieces of glass tubing which came with your outfit.

How to Prepare Glass Tubing

When you use glass tubing, it is a good thing to soften the edges at the ends by holding the tube in a hot flame for a few moments so as almost to melt the glass, if the ends are not already rounded; the ends of the tube may also be rounded with a file; but be sure to smooth the edges, or you will cut your tongue, your

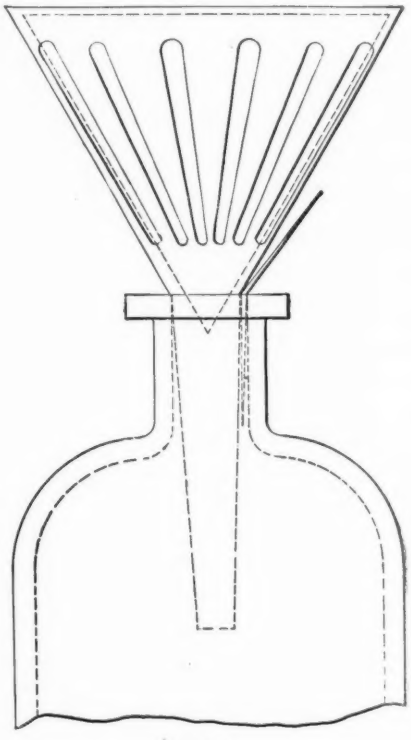


FIG. 4

corks, or your rubber tubing, and it is simply a matter of doing things shipshape *to round the edges* of glass tubing.

As you blow your breath into the limewater, and as you shake the liquid around, so that the gases of the breath can mix well with the liquid, you will notice that a whiteness comes in the limewater. It gets milky, and if left standing a white

sediment soon appears. This white sediment is lime (or calcium) carbonate. It is a union of the carbonic-acid gas from the breath with the "base," lime, and the two together have made the "salt," carbonate of lime (or calcium, calcium being the hidden metal that is at the bottom of the lime, just as iron is the metal at the bottom of common iron rust). The carbonic-acid gas in your breath came from the burning of the food in your body, by the millions of tiny furnaces in the muscles and red blood corpuscles; and the lungs make the chimney from which the invisible smoke of the breath gave off the carbonic-acid gas, just as truly as though the carbon of the food had been burned in your grate under your boilers. This shows again that the limewater is an active chemical. This is test No. 2.

You well know that all of your food contains carbon, the same element which makes up the bulk of coal. You know this from the fact that if the bread toast gets too much fire, it shows real coke or charcoal on the edges; and if your roast beef gets burned, there is the same coke or charcoal on the surface. You also know that bread and meat will burn in the fire as though they were of close kin to wood and coal; the same thing is true of sugar, starch and, especially, butter and fats. Now this turns your own attention to that fire right at hand. Why not test that with this limewater? You will do it in the following manner:

How to Apply the Test to the Furnace Fire

You will need a common wide-mouthed bottle, say, a horseradish bottle (see Fig. 5). Fit this with a good cork, which has two holes just wide enough to take in tightly the two pieces of bent-glass tubing *A* and *B*. Make the holes in the cork with the small blade of your knife, or with the cork cutter that comes with your outfit; then round the edges of the holes in the cork with a rat-tail file. The bent-glass tubes come with the outfit. You will note that one of these pieces of glass tubing goes just through the cork and the other piece reaches down below the surface of limewater which has been poured into the bottle. The tubing *A* is joined, by the bit of rubber tubing *C*, to the stump of a common clay pipe. You will want to try this piece of apparatus, by sucking with your mouth at the end of tube *B*. Naturally, bubbles will come through the limewater, as indicated by the arrows. Don't blow in this, unless you want to force the limewater out of the pipe. Your common sense will show you why. Now that you know that your cork and tubes fit fairly tightly, place some small, live and glowing coals from your boiler fire in the pipe bowl. There you have the real Turkish pipe, with well-cooled smoke; but what you are after is the action of the gas from the glowing coals on the limewater. It will not hurt you to suck some of this any more than it does to smoke your old pipe with tobacco in it.

As you draw the burnt gas from the glowing coals through the limewater, you will notice the same milkiness forming, and the same white sediment will gather as when you blew into the limewater with your breath, and for the same good reasons. The coal is mostly made up of carbon, and if you don't pack the coal too tightly in the pipe, you will not get much through that you need to note now except this carbonic-acid gas. This acid gas will unite with the lime, which is a base, and together the two will make the same white insoluble salt, carbonate of lime (or of calcium). Note that the lime, as such, is soluble to a considerable extent in water, while the carbonate of lime is *not* soluble; or, as they say, when a thing is *not soluble*, it is insoluble. As a matter of measure, it takes about seven or eight hundred parts of water to dissolve one part of lime (not very much, but enough to show well); and it takes some sixteen thousand parts of water (cold water) to dissolve one part of carbonate of lime; not very soluble, so it is called insoluble.

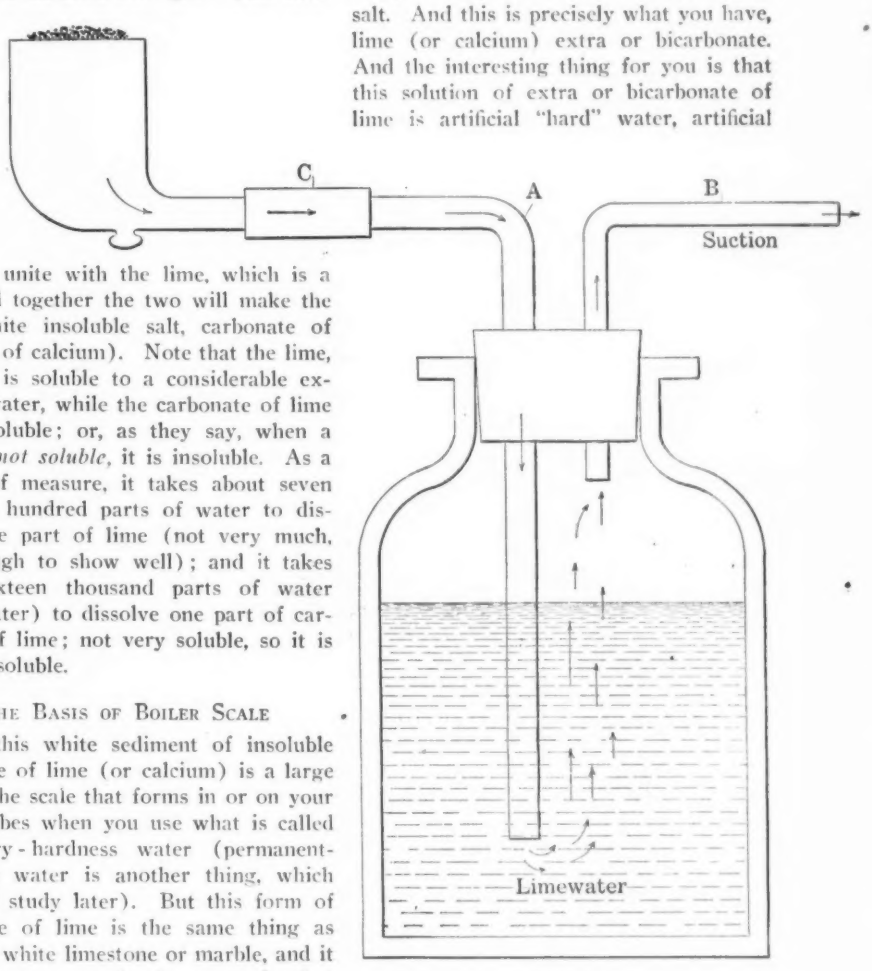


FIG. 5

The Basis of Boiler Scale

Now this white sediment of insoluble carbonate of lime (or calcium) is a large part of the scale that forms in or on your boiler tubes when you use what is called temporary-hardness water (permanent-hardness water is another thing, which you will study later). But this form of carbonate of lime is the same thing as common white limestone or marble, and it is the same as much of your scale; but what you want to know is this: If this white sediment is so insoluble in water, how does it get into the boiler, when your water supply is quite clear and shows no such thing, at least to the eye? You will see how to explain that if you go on to the next step with the limewater.

Go back to the beaker of limewater in which you blew your breath to bring down the white sediment of carbonate of lime. Take this and keep on blowing for some minutes, five or ten, shaking it about so that the bubbles of breath will mix thoroughly with the milky water. Pretty soon this will begin to clear up; not entirely, but a change will come in it. The sediment will partly dissolve, and it will look as though you could almost see through it. Now filter this off, through a clean piece of filter paper and with a clean funnel, into another bottle. Now you have a new kind of limelike water; it is not the original limewater, for it has gone through the throwing down as carbonate; neither is it the plain carbonate, for that is insoluble in water, while this is soluble enough to dissolve somewhat in water.

You can begin to guess for yourself what has happened. If you got the "salt" carbonate of lime, by adding the carbonic "acid" of the breath to the "base," lime, why here you must have a "salt" which has still *more* of the carbonic acid; in fact, an extra or bicarbonic-acid salt. And this is precisely what you have, lime (or calcium) extra or bicarbonate. And the interesting thing for you is that this solution of extra or bicarbonate of lime is artificial "hard" water, artificial temporary-hardness water. You can do something with this artificial temporary-hardness water that is exactly like what you do with it if you put it wholesale into your boiler. Just warm it, and the extra carbonic acid will go off, and down will come the white, insoluble plain carbonate; not very much, but enough to see and quite enough to make trouble when on a large scale. It was the extra carbonic acid which changed the plain *insoluble* carbonate into the somewhat *soluble* extra, or double, or bicarbonate, "hard" water in fact. The plain limewater is fairly soluble. From this you threw down plain carbonate of lime, by the breath and by the gas from the glowing coal, by means of carbonate-acid gas in the breath and in the "breath" of the glowing coal. This

plain carbonate of lime is *insoluble* in water. From this plain and *insoluble* carbonate you made some extra, or double, or bicarbonate (by adding extra carbonic acid); and this extra or double, or bicarbonate of lime is somewhat *soluble* in water. This is "hard" water, and it can be broken up and the limelike part thrown down again, as the *insoluble* plain carbonate; just as happens in making soft scale on your boiler tubes from your temporary-hardness water.

This temporary-hardness water can also be made, of course, not only by *blowing* the *breath* through limewater until the first plain *insoluble* carbonate has partly redissolved as extra or bicarbonate, which is fairly *soluble*, but also by *sucking* the gas from the glowing coals (as in Fig. 5) through the limewater in the horseradish bottle until it begins to clear again, say five minutes' suction with good glowing coals in the pipe bowl. After it begins to clear up, open the bottle, filter the water clear, pour it into a *clean* tumbler or beaker, and warm it. Enough plain insoluble carbonate will come down so that you will notice it if you look for it, and yet so little that one can easily overlook it if he doesn't look for it.

This is only the beginning of what that barrel of lime will teach you; but with all the bother of this fussy filtering, you may have done another piece of filtering which is worth your while, Mr. Furnaceman. That is, filtering out some clear ideas from the milky water of careless ignorance and prejudice. In the next article we will begin to discuss this filtering of new ideas, carefully and one at a time.

Electricity in Great Britain Mines

The appointment of an electrical inspector of mines in Great Britain is in itself an indication of the great strides being made in the application of electricity to mines. It is estimated that 50 per cent. of the new plant being put down in British mines is designed for production and distribution of electrical energy. The electrical industry is devoting a more intelligent study to the special conditions encountered below ground, on the one hand, to increase the safety and efficiency of the machine, and on the other to cheapen the cost. Mining engineers are now rapidly discovering advantages, from a purely mining point of view, in the use of electricity.—*The Mining World.*

At Charlottenburg 146 horsepower are transmitted by means of a belt, 10 millimeters = 0.39 inch in width and 5 millimeters = 0.185 inch thick, running at a speed of 61.5 meters a second, equal to 12,103 feet per minute, with a tension of 200 kilograms = 440 pounds. On the same shaft in another place is a 100-millimeter = 3.94-inch steel belt replacing a 600-millimeter = 23.6-inch leather one, both carrying 250 horsepower.

Calorimeter Tests of Steam

By W. H. Booth

Papers on power plants are often read, particularly in Europe, in which great weight is accorded to the calorimeter tests of the steam produced by a boiler. It is more or less amusing to note the assumption with which the reader of the paper sets forth his figures of 99.01 per cent. of dryness and the solemnity with which his listeners sit and receive such figures, and the natural sequel to such figures in the shape of some grotesque efficiency of the boiler which never could have given such an efficiency of dry steam. It is no part of this article to throw doubts on the accuracy of calorimeter instruments. Doubtless they give accurate results for the steam passed through them, but the crux of steam-dryness testing rests entirely with the sample of steam tested. The calorimeter tells what water there is in the small sample passed through it, but it does not, nor can it ever tell how much water is passing through the main steam pipe from which the sample is taken.

An old steam engineer was recently passing by a boiler which was being tested for the purpose of glorifying the particular mechanical stoker with which the boiler was fitted. The calorimeter test was in progress. "Why," asked the old man of the young experimenter, "do you take your sample of steam from that particular place? Why do you not use this cock which is specially provided and from which these samples of steam are to be drawn?" The reply of the young experimenter was as instructive as it was ingenious. "Because," said he, "the steam came so very wet at that tap and here I get it dry." And does not that reply give away the whole case for the calorimeter test?

From two points on one valve box or casing there was to be drawn steam wet or dry. Both the samples could not represent the truth of the matter. The test was made of dry steam. Yet the pipe was carrying a lot of water and this water was going to be counted unto the mechanical stoker for evaporation. Granted that the steam was not so wet as the one point showed it to be, it could not have been so dry as the other tap appeared to indicate.

All manner of devices and arrangements are put up with the object, or pretense, of drawing a correct sample. A pipe is turned toward the current of steam. It is fitted with a cross piece extending right across the pipe and perforated. An attempt is even made to draw steam through the sampling tube at the same velocity with which it is flowing in the main pipe, so that the correct proportion of water particles may be taken along. If such precautionary guess work is admitted desirable, is it not convincing proof that such sampling must be quite unreliable? No man can possibly say, with the most elaborate means of take off, that the calorimeter is being fed with steam of the quality the boiler is producing. Why, therefore, should the mockery of the test be continued? It was "sprung" on the electrical steam user as a piece of refinement which was demanded by modern conditions, and it has clung on as the obsolete and dangerous vermiform appendix has clung to mankind for long ages after he has ceased to hibernate and require such an addition. Indeed man today often dies of inflammation caused by the very nuts he once stored in the appendix that was made for such food.

But how can the quality of steam be really known which a boiler is giving forth? Plainly and bluntly it cannot possibly be known by any method short of testing the whole output in a suitable calorimeter. This plain statement refers solely to saturated steam. All saturated steam at a given pressure has a given temperature, no matter how wet or how dry it may be. The thermometer does not help us, for steam and water which come out of a boiler together have no temperature difference. But this very fact is a hint toward a certain elucidation of the problem.

Given a thermometer in the boiler steam space and another one of equal readings in the steam pipe, and a superheater in between, and the two thermometers will give, not the percentage of wetness, but that of dryness, and this dryness will always be over 100 per cent., or at least not less than that, if any reliance is to be placed on the figures of the test. One thermometer must read a trifle above the other, and when it does this it is proof the steam is dry. Some sort of a small superheater is therefore necessary if boiler tests are to be made for figures on which the slightest dependence is to be placed. Not one in all the many published boiler-test records is likely to be correct unless some slight superheat at least has been given to the steam.

The proceedings of the technical societies teem with boiler-test figures, books have elaborate tables of test figures, and conclusions are drawn from such figures and theories advanced on no better foundation than the baseless fabric of a vision. Boiler-test figures may be found showing very nearly 90 per cent. efficiency for the boiler alone, apart from the help of the feed heater. As the conjurer says after each of his juggling displays, "Isn't it marvelous?" It is. Any engineer who wishes credence to be lodged in his test figures should endeavor to have his test include for the superheater also, and in view of the present uncertainty as to the true specific heat of steam he should aim only to get a superheat of a few degrees, just sufficient to render it certain that there is superheat. Otherwise, no one who knows will place any value on the figures of his test.

Horatio Allen and the Novelty Works

Sketch of the Career of the Man Who Brought the First Locomotive to America and Became the Head of an Immense Engine Industry

BY EDWARD P. BUFFET

It was Horatio Allen who brought the first locomotive to America, who acted as running engineer on the first trip, and who later grew to be of the first magnitude as a builder of marine engines.

To understand how he came to import that locomotive we must look back to the time when the Delaware & Hudson Canal Company was pioneering what has since become a tremendous factor of industry, the transportation of anthracite to tidewater. At this time Horatio Allen was a young civil engineer just beginning to make his mark in life.

From Law to Locomotives

He was born May 10, 1802, in Schenectady, N. Y. His father, Dr. Benjamin Allen, a school principal, gave him a good start on the road of learning and at eighteen the boy graduated from Columbia College with high rank in mathematics. Those were days when none of the doors of a college opened directly upon technological walks of life, so that a young fellow who had been mingling on common footing with the rest of the scholastic herd would have been no more likely to have his attention called to engineering as a vocation than today he would be likely to select the profession of a sandwich man as a logical sequence to taking his degree.

It is therefore not to be wondered at that Horatio Allen at first set about reading law, as his later engine-building contemporary, Charles T. Porter, and many others have done, from lack of reason to the contrary if from no more rational motive. But it took him less time than it did Mr. Porter to discover his real adaptedness and switch off upon the right track. So at about the time he cast his first vote he entered the employment of the Delaware & Hudson company. Afterward he spent a year or two upon the Chesapeake & Delaware canal, but near the close of 1825 he was appointed resident engineer of the summit level of the Delaware & Hudson canal under the eminent John B. Jervis. That brings us to the point where we started, when the company was hauling out its coal by canal and when locomotives did not yet exist on this side of the Atlantic.

In Quest of Knowledge and Engines

The performances of the steam locomotive on the Stockton & Darlington road in England were arousing the interest of American engineers, and in particular of Horatio Allen. Though at an age—twenty-five—when most men rightly feel that they must establish their reputation by steady service with going concerns before cutting loose and offering themselves to the world as technical leaders, Allen threw up his job in order to go to England and acquaint himself with what, he was convinced, would prove the carrying power of the future. But perhaps he already had the situation better in hand than appears, for previous to sailing, he received a commission to act as agent for the Delaware & Hudson company, empowering him to procure railroad plates and one or more locomotives for a 16-mile railroad which it was building to connect its mines in Pennsylvania with the canal. One locomotive the company desired as a pattern for construction of additional engines in the United States; as an alternative to which plan it might wish to have them all made in England. The ultimate decision was to procure three there. The company agreed to pay Mr. Allen's passage and expenses, permitting him to remain abroad about three months, the whole not to exceed $900.

Railroad plates of the sort mentioned were primitive rails ½ inch thick by 2½ inches wide at the bottom and 2 inches at the top and 12 to 14 feet long, to be laid on wooden string pieces. It was desired to have the edges rounded if this would not entail too much additional expense. Further, Mr. Allen was asked to report on improvements in coal "wagons," especially as to the size of wheels and manner of connection to the axles. Mr. Jervis wrote him a long letter filled with specifications for his mission.

Visit to Stephenson

Leaving New York in January, 1828, Mr. Allen arrived at Liverpool, where he was cordially received by George Stephenson. The famous trial of the "Rocket," on the Liverpool & Manchester railroad, was not destined to take place until October 14, 1829, in the spring of which year the directors still vacillated between locomotives and fixed engines for the road. The fixed engines would presumably have been used on inclined planes in connection with gravity switchback grades, which arrangement seems to have been a favorite one in the early days of railroading and which still may, or recently could, be seen in operation in the anthracite region of Pennsylvania. Locomotives had, however, been in successful service at Killingworth, Eng., as early as 1814, and there were in use on the Stockton & Darlington railroad locomotives of a common type which the instructions from Mr. Jervis favored. In compliance with the opinions of his chief, Mr. Allen ordered one of this model from Foster, Rastrick & Co., of Stourbridge. It had four coupled wheels, all drivers, two vertical cylinders of 36-inch stroke, placed at the rear of the boiler, "grasshopper" beams, wooden-spoked wheels and cylindrical boiler with several large flues. The blankness of the circular space on the front of the boiler was embellished with a lion's head, whence this engine was dubbed the "Stourbridge Lion."

The "Rocket" and Its Predecessors

While Mr. Allen deferred to the home ideas in ordering one locomotive of this type, he profited by Stephenson's influence sufficiently to contract with that inventor's firm, at Newcastle, for two other engines essentially of what later became celebrated as the "Rocket" type. These, when brought to New York, were stored for awhile in the city, where exhibitions were given with wheels running free of the ground. From this point they are lost to history and it is the "Stourbridge Lion" which is known as the first locomotive on an American railroad. If the "Rocket" type engines had been put into service at once, their trial in America would have antedated the proval of that design in England.

First Locomotive Run in America

The "Stourbridge Lion" was held up during the winter of 1828-29 by the closure of the Delaware & Hudson canal with ice, but reached Honesdale, Penn., in the spring and on the ninth of August, 1829, made its maiden trip on the road from the canal into the Pennsylvania woods where the mines were situated. The engine crossed the Lackawaxen river by a curve on a trestle, where the poorly seasoned timber had brought the rails dangerously out of true. To Mr. Allen fell the honor of acting as engineer and complete crew on this first run, which the numerous spectators believed would necessarily be his last. His last, indeed, it proved, though not because of any catastrophe. Our thrills at his hazard may be abated by reflection that the normal speed

of such an engine in service was only 4 to 6 miles an hour, and had it jumped the track at that velocity he might have stepped off upon the ties without losing his cigar. However, he was at the time running without load and may have speeded up the machine enough to startle the beholders.

More than half a century elapsed before Horatio Allen again visited the scene of his exploit, which occasion was marked with lively emotions at the memories it awakened.

Railroading in South Carolina

The month after his epoch-making run, Mr. Allen became chief engineer of the South Carolina railroad. It was then in question whether to employ horse or locomotive traction there, and his counsel in favor of the latter was unanimously accepted by the directors. As he has stated in his pamphlet, "The Locomotive Era," there was no reason to expect any material improvement in the breed of horses, but in his judgment the man was not living who knew what breed of locomotives the future was to place at command.

By his recommendation the gage of the road was made 5 feet, but a similar suggestion that he later made to the Erie road was rejected, to the great disadvantage of modern heavy railroading. A railroad gage is one of the standards which it seems impossible to change and which is snatched at by the anti-metric cranks as an argument against changing any.

Invention of the Swiveling Truck

To Horatio Allen is due a large share, if not the whole credit, of originating the swiveling truck. The light plates on 6x12-inch stringers which then served for rails were incapable of sustaining a heavy weight, the safe load on the Liverpool & Manchester railway being three tons, or even less, per pair of wheels. Hence the limitation of locomotive wheels to four necessitated the use of light engines and entailed correspondingly heavy operating expense in transporting a given quantity of freight. In 1831, Mr. Allen called the attention of the South Carolina railroad directors to this difficulty and recommended the employment of more than four wheels, with swiveling trucks to enable the passage of curves. Consequently he was empowered to place contracts with the West Point Foundry for locomotives built on that principle. The first of these was the "South Carolina," and put in operation early in 1832. A couple of years later a patent was granted to Ross Winans, of Baltimore, for eight-wheeled cars with two trucks. Some such were built or used by the Newcastle & Frenchtown Turnpike and Railroad Company in defiance of Ross' patent claim. This led to twenty years' expensive litigation, virtually involving the interests of all the railroads, and it was not until 1858 that Winans' patent was finally declared invalid. During the dispute recourse was had to evidence that the double-truck principle had been employed before the patent date by Horatio Allen.

The South Carolina railroad locomotives of this type were double-enders, consisting of two engines facing apart and joined by a firebox in the middle. Each boiler was double-barreled and rested on a four-wheeled, jointed, swiveling truck, there being one cylinder to each truck.

John B. Jervis himself was another pioneer in using the truck form of construction and seems to have been at least a close second. The truck idea had, indeed, been foreshadowed as long ago as 1812 in an English patent to William and Edward W. Chapman.

After completion of the South Carolina railroad, Mr. Allen was variously occupied. He married, traveled abroad for two or three years and served as principal assistant engineer of the Croton aqueduct under his old chief, John B. Jervis.

The Novelty Works and the "Novelty"

Horatio Allen's *Lehrjaehre* and *Wanderjaehre* came to a close in 1844, or thereabouts, when he entered, as one of the proprietors, that famous engineering works in New York City with which his subsequent career is identified. He became a member of the firm of Stillman, Stratton & Allen, owners of the "Novelty Works."

About the early part of the thirties, Rev. Dr. Eliphalet Nott, president of Union College, Schenectady, N. Y., who had been active in introducing anthracite for house stoves, invented a steam boiler to run on that fuel and decided to build a steamboat in which to make a test. Besides burning this novel fuel, he proposed to install a novel mechanical equipment throughout, wherefore the boat was called the "Novelty." This name attached itself to a shop which he established to do repair work, etc., on the vessel. It consisted of a wharf and some buildings situated in New York City, on Burnt Mill point, so-called, at the foot of Twelfth street, East river. The "Novelty" herself ran from New York to Harlem. The Novelty Works gradually extended its attention to outside business, and from an equipment of a few tools in a little shed, grew to be the biggest marine-engine building establishment in the country.

Development of the Works

In the early days the business was conducted by Nott & Co., under superintendence of N. Bliss, formerly of the West, the foreman being Ezra K. Dodd, who afterward was made chief engineer of the "Novelty." Later Thomas B. Stillman took charge of the plant and, in 1838, it passed into the hands of a firm including himself, John D. Ward, Robert M. Stratton and C. St. John Seymour. Messrs. Ward and Stillman were the mechanical men of the firm. Among the work turned out were two ocean steamers, the "Lion" and "Eagle," for the Spanish government. Mr. Ward retired from the firm in 1841 and Mr. Seymour not long afterward, Mr. Allen being admitted about 1844. Eventually he secured practical control of the enterprise with the financial aid of Brown Brothers, bankers, Mr. Stillman retiring.

In 1855 the concern was chartered as a corporation with $300,000 cash capital, the corporate title, "Novelty Iron Works, of New York," expressing what had from the beginning been its popular designation. Horatio Allen became its president and dominating spirit.

A Great Old-time Engine Shop

It may be of interest to summarize an account of the Novelty Works given about the time of the war, in order to estimate how progress in similar plants has been made between that period and the era of West Allis and East Pittsburg.

Near the entrance gate, with its porter's lodge and offices, was a large crane for handling shafts, cylinders, boilers, vacuum pans and other ponderous pieces of machinery. To the left was the iron foundry, 206x80 feet, with a wing. It contained four cupola furnaces capable of melting at one heat 65 tons of iron, which could be cast into one mold. There was also another furnace. The foundry blast was led through an underground pipe of 5 square feet sectional area. Some of the foundry cranes were as strong as 20 tons load. Here were made the bedplates for the steamship "Atlantic," weighing 37 tons, and for the "Arctic," 60 tons. In the summer of 1854 there was cast the cylinder of the steamer "Metropolis," of the Fall River line, having a diameter of 105 inches and a length of 14 feet, with 12 feet stroke of piston. Twenty-two people sat down to lunch in the cylinder, with room to spare, and a horse and chaise were driven through it.

The smiths' shop was equipped with thirty forges, hammers and some cranes of large capacity, evidently of gib type. In one case a piece of iron weighing 14,366 pounds had been forged and handled. There were also machine and finishing shops, two boiler shops, etc., each with its appropriate machinery.

The whole establishment was divided into twenty departments, each having its foreman, viz.:

Iron founders, brass founders, machinists, boilermakers, carpenters, coppersmiths, blacksmiths, metallic lifeboat builders, instrument makers, hose and belt makers, painters, masons, riggers, laborers, cartmen, watchmen, storekeepers, patternmakers, draftsmen and clerks. All told, an average number of more than 1000 men were employed, and the work turned out amounted to some $1,330,000 a year. At one time over 1500 men were employed and owing to the scarcity of

labor Mr. Allen went to Europe to obtain hands. The works occupied nearly two blocks and included two slips sufficient in size for the largest steam vessels. Machinery for many of the old Collins line and Pacific Mail steamships were built there. In addition to marine work the company turned out a varied line of mechanical products, such as stationary engines, pumps, sugar machinery, steam fire engines, and hydraulic presses.

Allen's Engineering Faith and Practice

Horatio Allen was a firm believer in oscillating-cylinder engines as compared with beam engines for sidewheelers. He wrote a pamphlet, 1867, claiming for them superiority in compactness, lightness, simplicity and application of power. An "objective point" (to borrow a term from a certain Mrs. Malaprop of our acquaintance) seems to have resided in the valve mechanism. An experimental valve gear which Mr. Allen applied to the engines of the "Adriatic" caused so much trouble that it had to be taken out. It employed large conical-plug valves with a device for lifting them to be turned, so as to prevent their jamming. It would probably be indulging in unwarrantable panegyric to describe Mr. Allen as a great inventor. But he believed in himself and he disbelieved in Sickels, of whom he considered himself a standing rival, and whose cutoff, C. T. Porter says, he would never allow to be applied at the Novelty Iron Works. The same authority tells us, however, that Mr. Allen, in his later years, when judging at the Centennial, united in an award to Sickels with an expression of cordial admiration.

At the time of the war the Novelty works built engines for several vessels of the Federal navy, including the double-turreted monitor "Miantonomah."

From this period dated a long controversy in the navy upon the economy in using steam expansively. Chief B. F. Isherwood, of the Bureau of Steam Engineering, and others, advocated moderate pressures with moderate ratios of expansion, while their opponents, including E. N. Dickerson, advised high pressures and high expansive ratios. The dispute became so animated that a commission was formed under Government auspices to make tests and, if possible, answer the question. These experiments were carried on at the Novelty works, largely under direction of Mr. Allen, who was of the high-expansion party, but who suspended judgment during the trials.

These investigations lasted so many years that the world grew weary of waiting for the results and the Government tired of paying for them. It seems that the points at issue were not all clearly settled and the results did not go to vindicate the extreme claims of either party. The data collected tend to show that with increased pressure the economical point of cutoff shortens, but that with any pressure the most economical degree of expansion is soon reached and further expansion rapidly grows wasteful.

Subsequently Commodore Isherwood and Mr. Dickerson arranged a series of comparative tests of the "Winooski" with Stevens cutoff and double poppet valve, 60 pounds pressure and cutting off at sixtenths of stroke, against the "Algonquin," with Sickels cutoff and single poppet valves, 90 pounds pressure and cutting off at one-tenth stroke. The "Algonquin" failed.

The Closing Years

Engineering work flourished during the war and the Novelty works were kept very busy. But their profits were not correspondingly large. The cost of labor and materials was constantly advancing, and since the machinery built was of a sort that often required a considerable time to complete, the tendency was for expenses to exceed the estimates underlying contracts. In later years business slackened. Meanwhile the equipment was growing old and the real estate occupied by the plant had become very valuable. All things considered, it seemed wise to wind up the business, and about 1870 this historic establishment passed out of existence.

Mr. Allen survived the works a score of years. His death occurred within a few hours of the close of the ninth decade of the century, at his home near South Orange, N. J.

Horatio Allen made a variety of inventions, from 1841 to 1879, those among them relating to steam cutoffs and valve gears standing out conspicuously. Toward the close of his life he interested himself in methods of teaching astronomy and constructed a number of instruments for the purpose. He was the author of an elementary book on arithmetic.

During his connection with the Novelty works his eminence in his profession was recognized by a number of outside appointments. Thus, he was made consulting engineer for the Erie railroad, the Panama railroad and of the Brooklyn bridge. He also served a term as president of the Erie.

Horatio Allen has been marked by his contemporaries both with criticism and with praise. A tendency to dissent from some of his opinions is manifest in the "Engineering Reminiscences" of Charles T. Porter, who, among other disparaging remarks, animadverts upon Mr. Allen's tiresome fussiness as president of a group of judges at the Centennial.

On the other hand, he is spoken of with high encomium by his old friend, M. N. Forney, who upon his death published in the *Railroad and Engineering Journal*, which Mr. Forney was then editing, and afterward in pamphlet form, a biography with some interesting old documents relating to his early locomotive experience. Mr. Forney describes him as a man of broad tastes and interests, gentle and appreciative, encouraging to young men and unswerving in his integrity. He was strong in his indignation toward such methods of business bribery as have become common in our days of the exaggerated dollar.

New Turbine Plant for the Atlantic Mills

Plans for a central power plant of 5000 kilowatts capacity have been completed by the management of the Atlantic Mills, one of the largest textile concerns in Rhode Island, and a contract was awarded for a 1500-kilowatt Westinghouse-Parsons steam turbine to be delivered about April 1, when it is presumed the new station will be ready for the installation of the first unit.

On the extensive property of the Atlantic Mills are several reciprocating engines varying from 500 to 1500 horsepower. These will be superseded by the steam turbines and electric drive will be substituted for belt drive.

To steam engineers the novel feature of the new power house of the Atlantic Mills is in the selection of a turbine of the noncondensing type designed to give maximum economy when operating against a slight back pressure. All of the exhaust steam, amounting to approximately 60,000 pounds per hour, will be utilized in the various manufacturing processes in which live steam now is used, these processes being for the most part in the dyehouse. This use of exhaust steam is not in itself wholly new, but it is unusual to find a dyehouse large enough to require the exhaust from so large a turbine as one of 1500 kilowatts. The Atlantic Mills dyehouse, it may be stated, is one of the largest in the country.

The noncondensing operation of steam units has been restricted very largely to reciprocating engines, and the operation of a turbine noncondensing is considered exceptional. The Atlantic Mills is one of the first to adopt this method and it is expected that the saving over the present arrangement of using live steam will be pronounced. Even in noncondensing service the turbine builders expect to demonstrate that the turbine will make a good showing in economy as compared with a reciprocating engine, both under test conditions and in daily service year after year.

One advantage is claimed for the turbine exhaust—it furnishes steam free from oil, which is necessary in the processes in which the steam comes in contact with textile goods.

The Alinement of New and Realinement of Old Shafting

By James Lomas

While discussing this subject with a friend of exceptional experience, he ventured the astounding remark that it would be impossible to find a line of shafting in any mill or works in approximately true alinement. There is undoubtedly much truth in his statement.

The importance of shafting being correct in its position, that is, level in its bearings and in a perfectly straight line sidewise the whole length, cannot be overestimated. Those persons of experience who have had to deal with the faults and follies of incorrect and badly executed work, know well the extra cost of maintenance requisite to keep a mill or works in constant operation; overtime for the engineer-in-charge; occasional stoppage of the machinery through needless friction in the bearings; wheels, pulleys and couplings loosening daily, and breaking; extra cost of fuel and labor in the fire room; extra wear and tear of the engines, etc. These are only some of the troubles attributable to shafting not being in alinement.

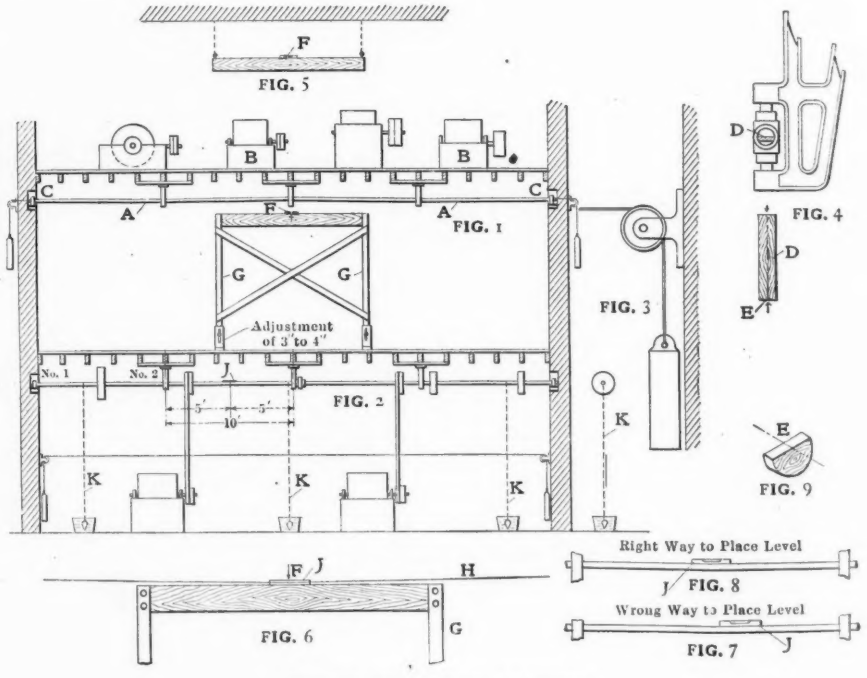
The causes of all these troubles are manifold. On new work the system of erecting generally carried out is unquestionably faulty; and such faults may arise from many sources, such as the settling of the foundations of the building, the warping or twisting of the floors where wood beams have been used, the distortion in structural steel and iron work; and where fireproof floors are constructed either of brick, concrete or similar material and the shafting is erected before the floors are thoroughly set and dry (and this usually takes considerable time), the result of the millwright's labor will be unsatisfactory. As soon as a mill or workshop building is sufficiently advanced in construction to enable the millwright to fix the hangers or brackets he is generally told to do so. Often this occurs before the windows are in their places. The reason for doing this is because there is much to be saved in cost of erection. The room is clear of obstructions and this simplifies the work very much; scaffolding is often at hand and there are many other conveniences which help the work forward. This method, of course, suits the workman, the contractor and the owner, and on first sight appears strictly economical, as it gives a quickly executed and cheap job. But after giving the matter fair consideration it will readily be found to be false economy and an increasing extra expenditure will be requisite until the work is remedied. To illustrate this refer to Fig. 1, where *A A* shows a line of shafting attached underneath a floor, above which a quantity of heavy machinery is being installed. The weight of the machinery has distorted the floor; the shafting, of course, is out of alinement, no matter how carefully the work was done before the heavy machinery was placed in position.

The same thing occurs if a line of shafting is carried on a ground floor through floor stands or pillow blocks, as the floor or foundation is almost sure to settle. Luckily, the remedy is simple if those who are responsible can be led to see it. The logical system to adopt is to allow the mill to be finished and the shafting erected before the machinery is fixed. Then a short time before the machinery is put in operation realine the shafting and make all the bolts, etc., secure; the shafting is much more likely to run under better conditions and for a longer period without attention except the usual oiling and cleaning, etc.

Of course, many people will be tempted to think this system entails a lot of unnecessary labor, but if they will reason the matter out and place the work in skilled hands, I venture to say they will be well satisfied with the result, as they will unmistakably save money.

Let anyone take the trouble to test a line of shafting erected under the first-named conditions, when the shafting has been at work three months, and he will require no further confirmation that the system is entirely wrong. However, under any circumstances it is necessary to have a second alinement to obtain the best results, and if strict economy is to be considered a periodical alinement should be made, say, every twelve months. Of course, the bearings should be under constant examination.

If the reader will study the method of the realinement of old shafting shown in Fig. 2-*J* its simplicity will be apparent, and the cost of putting mill shafting in order will be a mere fraction compared to the advantage gained. Let mill owners think for one moment of the continual loss occurring through the defective condition of their mill shafting, that has probably been working for years without any attention further than the usual oiling. As long as the motive power is sufficient to move the shafting around it is not considered necessary to do anything more until suddenly there is a smash and everything is stopped, sometimes for days. Yet to remedy all this is such an extremely simple matter to the practical man, as will be seen by again referring to Fig. 2-*J*, and the benefits to be derived therefrom need not be further commented on. The work of realining may be done when the mill is stopped for a holiday or at a week-end, and little or no inconvenience need be suffered by anyone. I have undertaken many such jobs and in no case has it taken more than two week-ends to complete a fairly large job. It has been found that the shafting has been frequently out of level from ½ inch to 2 inches. In one case, that of a new mill with the shafting erected by one of the best known firms in the country, the shafts were 2½ inches diameter and the distortion was owing to the steel beams that the hangers were attached to and which were imbedded in a fireproof ceiling; the floor above was covered with heavy machinery. The irregular torsional strain on the shafting was the cause of about a dozen ends of shafts twisting off and the split muff couplings were constantly coming loose. This went on until the whole of the shafting had been realined, although the mill had not been at work more than twelve months.



DEVICES FOR ALINING SHAFTING

Where the shafting is carried in adjustable bearings the leveling is a simple matter, but where nonadjustable fittings are in use the work is much more difficult, still not so much so but that intelligent workmen can deal with it. The best line to use for the purpose is piano wire which, when used as shown in Fig. 3, gives very little deflection or sag. The next best is the strongest line procurable, but fairly fine.

How to Erect and Aline Shafting

Having determined the position and type of hanger, wall bracket, pillar bracket or pillow block to be used, fit the two end bearings in position. Next secure the line as short a distance as possible beyond the end of each bearing. The usual method of so doing is by driving a spike into the wall or other convenient place. The line is carried through the end bearings, pulled taut and made secure. This method is very unsatisfactory, inasmuch as from various reasons considerable deflection or sag occurs; consequently, the line requires to be repeatedly tightened. A much better method is shown in Fig. 3; a bracket with pulley is fixed at each end of the shaft line and the line placed through the end bearings. A weight is fastened to each end of the line (see Figs. 1 and 2). Thus the line is kept taut without further trouble.

At this stage it will be necessary to get the line level from end to end, having placed in each end bearing a strip or float, made as per Fig. 4, and secured the bearings so as to hold the strip firm with the central line marked *E* on the strip parallel to the line (cord or wire) that the rest of the bearings are to be fixed by. Then proceed to fix the straight-edge, the center of which must be exactly at half distance between the end bearings. This point is very important, for if placed at an unequal distance between the end bearings, the deflection of the cord will mislead the erector. The straight-edge may be carried by a cord attached to each end and hung from the ceiling; see Fig. 5-*F* or a temporary frame made as per Fig. 6-*F*, whichever is the most convenient under the circumstances. Having carefully leveled the straight-edge, adjust the two fixed hangers so that the cord will be parallel to the straight-edge. Then, having made that secure, notice the deflection in the cord *H*, Fig. 6, and a simple calculation will show the relative position of the central hanger.

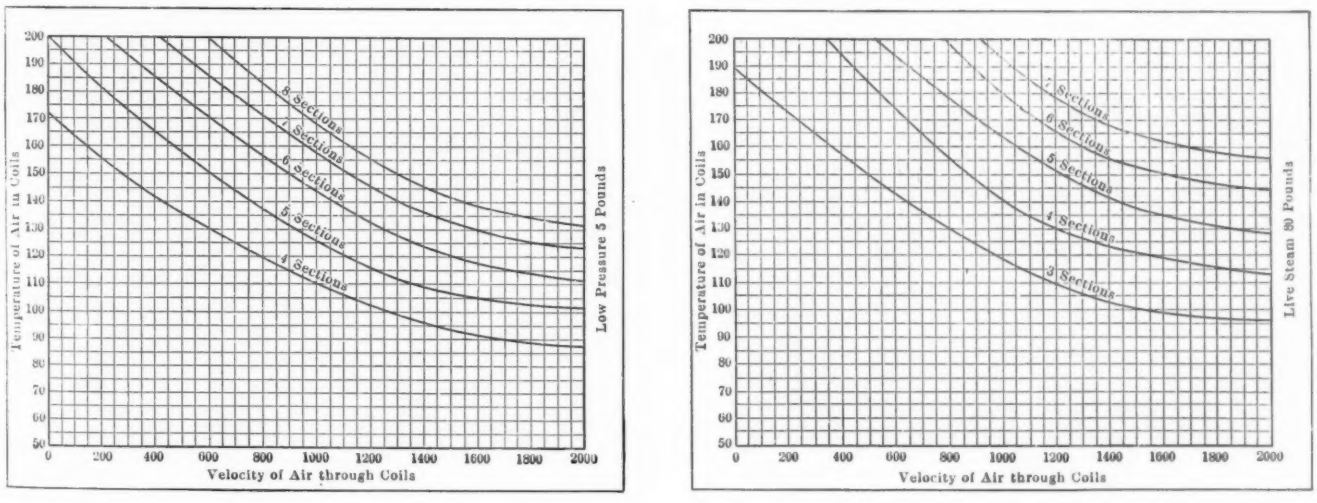
Next, fix the central hanger, making allowance for the deflection of the cord line; having made this secure place a wood center as per Fig. 9-*E* in the middle of this center bearing to support the cord line. There will then be very little deflection on the cord line in the intermediate distance between the central and end hangers. The rest of the hangers may then be fixed in position and made secure. Having fixed such hangers in position the shafting may then be placed in the bearings, the couplings fixed in their position and made good, having made everything all right by fixing the caps on the bearings, etc. The shaft may be revolved to insure it being properly placed in the bearings before the leveling is done. The spirit level *J* should be a reliable make, 18 inches to 2 feet long, and adjustable. When using it on the shaft it should be exactly central between the bearings, as there will be some deflection in the shaft, and if tested on one side of the center between the bearings the erector will be misled. See Figs. 7 and 8-*J*.

If the work has been carefully carried out up to this stage, it will be found that very little adjustment will be necessary. The next thing is to test it sidewise, and having finished with the cord line on the shaft level, refix it at a convenient distance from the floor, say 3 or 4 feet. But first, drop a cord line from each end of the shaft with a heavy plumb bob or weight attached and let the latter hang in a pail of water. See Fig. 2-*K*. This insures steadiness of the plumb line. Then carry the cross line, Fig. 3, the whole length of the shaft and adjust it so as to be about 1/64 inch clear of the dropped line at each end. Then by dropping a plumb line from each bearing as shown in Fig. 2-*K*, begin at No. 1 and test one at a time with the same plumb line until the whole have been tested.

To realine a shaft where the place is filled with machinery it is necessary only to carry out the aforenamed instructions, excepting that a scaffold or other convenience may be required above the machinery. In erecting nonadjustable hangers on brackets, the adjustment is obtained by using wood or other packing pieces between the base of the bracket and the beam, making the work much more difficult. Yet the instructions given herewith generally are applicable, except that each bracket or hanger should be leveled by resting the straight-edge in the previous one and spanning the two, beginning at No. 1 and proceeding to the end. The straight-edge should not be less than 12 feet long, 10 to 12 inches wide and 1¼ or 1½ inches thick, and the two edges will be exactly parallel.

Heating Power of Steam Coils

The amount of heat transmitted per square foot of heating surface from steam coils naturally depends upon the difference in temperature between the steam on the inside and the air upon the outside. But the air temperature close to the pipes is largely influenced by the rate of flow across the surface. When the air remains practically stagnant the condensation will be but a fraction of a pound per hour per square foot, but as the velocity increases so also does the condensation, which is a direct measure of the heat which is transmitted, and the condensation will run up into pounds per hour for the same surface



CURVES SHOWING EFFECT OF STEAM COILS IN HEATING AIR

area. Manifestly the higher the velocity the more rapid will be the rate of transmission; hence the primary advantage of the blower system of heating under which the air is compelled to pass rapidly across the surface of exposed steam pipes.

The ultimate temperature given to the air passing across a stack of steam coils must depend not only on the steam pressure, but on the initial temperature of the air and above all on the arrangement of the pipes. The less the depth of the heater or the distance across which the air passes the greater will be the condensation per unit of surface, but the less will the temperature of the air be increased. Intensity of temperature with a given steam pressure can only be obtained by depth of heater.

These relations are not generally known with exactness except by those directly interested in the manufacture and installation of such apparatus. Special interest, therefore, attaches to the accompanying curves from the catalog of the Massachusetts Fan Company, Watertown, Mass. Without going into details of construction or conditions these suffice to show that minimum velocity and maximum depth of heater are essential to intensity of temperature. Between these extremes lies average practice with heater depths ranging from four to six sections (16 to 24 pipes) and velocity from 1200 to 1800 feet per minute.

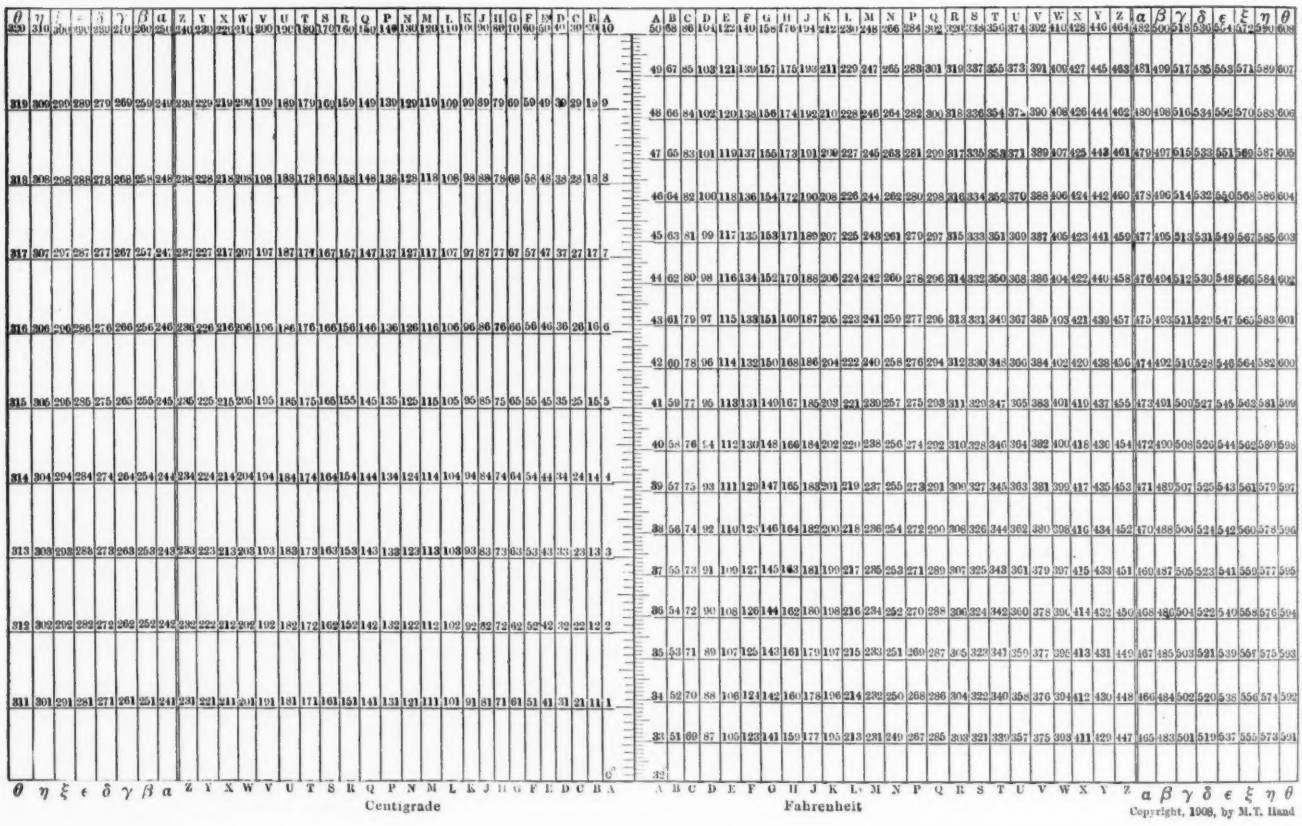
Scale and Table, Giving Epuivalent Graduations of the Fahrenheit and Centigrade Thermometers*

By M. T. Hand

The accompanying scales and chart are intended to give at a glance, without any calculation, the equivalents between any degree or tenths of a degree of the Centigrade and Fahrenheit thermometers. In the center of the chart is shown a double scale divided into degrees and tenths of a degree. The scale on the right is the Fahrenheit thermometer scale and that on the left is the Centigrade thermometer scale. It will be noted that from the graduations of the Fahrenheit and Centigrade scales each portion of the Fahrenheit scale, advancing by 9 degrees from the freezing point, has a coincident portion of the Centigrade scale advancing by 5 degrees. The chart is based on this duplication of scale. It is necessary, therefore, only to lay out to any scale nine equal divisions, subdivided into tenths if desired, using this as the Fahrenheit scale, and then dividing the space on the other side of the vertical into five equal divisions, subdivided into tenths, to have the corresponding equivalents of the Centigrade scale.

In order to make the chart symmetrical and easy to read a scale of 4½ inches for 9 degrees Fahrenheit was used and then doubled. The reproduction is on a reduced scale, of course. Instead of extending this scale in a vertical line, the recurring points on each scale have been placed on a horizontal line, i.e., the point showing 9 degrees above freezing on the Fahrenheit scale or 41 degrees Fahrenheit actual reading, has on the scale as laid out the same relative position as 59 degrees Fahrenheit, 77 degrees Fahrenheit, 95 degrees Fahrenheit, etc. Also 5 degrees Centigrade has the same relative position as 15 degrees Centigrade, 25 degrees Centigrade, 35 degrees Centigrade.

To use this chart the whole degrees of either the Fahrenheit or Centigrade thermometers are found opposite each other in corresponding columns on either side of the scales. For example, 185 degrees Fahrenheit, which is found in column *J* of the right-hand side, has its equivalent in column *J* of the left-hand side directly opposite, namely, 85 degrees Centigrade. For tenths of a degree of either thermometer the corresponding tenths of the other thermometer are read directly from the scale, i.e., if the example had been to find the Centigrade equivalent to 185.5 degrees Fahrenheit, the whole degrees would have been read as stated from the chart,



SCALE AND TABLE GIVING EQUIVALENT GRADUATIONS OF THE FAHRENHEIT AND CENTIGRADE THERMOMETERS

*Copyright, 1908, by M. T. Hand.

while the graduation of the right or Fahrenheit side of the scale, five divisions above the horizontal line marked 185 degrees Fahrenheit, is at once seen to be opposite the graduation equivalent to 0.28 degree on the Centigrade scale. Therefore, 185.5 degrees Fahrenheit equals 85.28 degrees Centigrade. To familiarize the reader with this process several examples and answers are given below:

EXAMPLES

Change 296.8 degrees Fahrenheit to Centigrade: 296 degrees Fahrenheit is found in the right-hand chart column *Q*. In the left-hand chart column *Q*, and nearest the horizontal line opposite, is found 147 degrees Centigrade, while on the scale on the left-hand side and across from the graduation corresponding to 0.8 degree Fahrenheit above the horizontal line marked 296 degrees Fahrenheit is found the graduation to give 0.11 degree Centigrade. The total result is, therefore, 296.8 degrees Fahrenheit equals 147.11 degrees Centigrade.

Change 200.3 degrees Centigrade to its equivalent Fahrenheit reading: 200 degrees Centigrade is found in the left-hand chart column *V*. In the right-hand chart column *W*, on the horizontal line opposite, is found 392 degrees Fahrenheit. As the top of the scale has been reached, return to the bottom for the fraction of a degree above 200 degrees Centigrade, and accordingly across from the graduation corresponding to 0.3 degree Centigrade at the extreme bottom of the scale is found the Fahrenheit scale graduation 0.54 degree Fahrenheit. Therefore, 200.3 degrees Centigrade is equal to 392.54 degrees Fahrenheit.**

Change 411.5 degrees Fahrenheit to Centigrade: 411 degrees Fahrenheit is found in column *X* on the right-hand chart. In the left-hand chart column *X* is found 211 degrees Centigrade on the horizontal line nearest opposite the horizontal line indicating 411 degrees Fahrenheit, but this line is above the Fahrenheit reading it is desired to transpose. It is, therefore, evident that the whole degrees Centigrade corresponding to 411 degrees Fahrenheit is not 211 degrees Centigrade, but 210 degrees Centigrade. Then read the fractional part of the Fahrenheit temperature directly across from the 0.5 degree Fahrenheit scale as 0.83 degree Centigrade. Therefore, 411.5 degrees Fahrenheit is equal to 210.83 degrees Centigrade.†

**Use especial care in reading from the bottom of the chart to add the total number of tenths corresponding to the Centigrade graduation, i.e., 0.9 degree Centigrade is equivalent to 16 tenths plus, on the Fahrenheit thermometer scale, so that 200.9 degrees Centigrade is equivalent to 392 degrees Fahrenheit plus 1.62 degrees Fahrenheit, or 393.62 degrees Fahrenheit.

†Use care when reading from the bottom of the Centigrade chart not to read 1 degree too high. The degree readings corresponding to the horizontal line at the extreme bottom of the chart have been omitted, to avoid confusion by finding the same reading in two different columns.

A little practice will enable one to immediately make these transpositions from one thermometer reading to the other.

A "Valveless" Engine

BY W. H. BOOTH

A novelty in engine work appeared at the Olympia exhibition of motor cars in London recently. It was described as a valveless engine and was of French origin. Actually, however, it was not a valveless engine, but was a curious adaptation of the slide valve with movable seat, of which one may read in Rankine. This particular adaptation is only rendered practicable by reason of the petrol engine being single-acting with an open-ended cylinder. Conceive of a cylinder with a bore about ½ inch larger than the piston, leaving an annular space between the cylinder and piston of ¼ or 5/16 of an inch. Into the closed end of the cylinder projects the cover, the projecting boss being of the same diameter as the piston, so that there is a deep annular space around the projecting boss.

In the cylinder, fitting closely one inside the other an easy working fit, are a pair of ground cylindrical shells longer than the cylinder and of such a thickness that while the smaller one fits nicely within the larger, the former acts as the cylinder for the piston and the larger one slides nicely inside the actual cylinder. The smaller shell projects farthest outside the open end of the cylinder and has upon it a pin attachment for a pivoted valve rod. The larger shell is a little short and has a similar attachment. The two are caused to work up and down by eccentrics on a shaft driven from the crank shaft of a 1:2 chain gear, so as to suit the Otto cycle of a petrol engine. Both shells project into the space about the cover projection.

The cylinder has an inlet port nearly halfway around it, a little below the cover projection, and an exhaust port at the same level nearly half around the opposite side of the cylinder. The inner shell has similar ports, also at the same level, and the outer shell has similar ports, but the exhaust port is lower than the inlet port. Both shells project up into the cover annular space, and the combination forms an annular slide valve with movable seat, thus securing with a short travel the operations of fuel inlet, compression, explosion and expulsion in the four-stroke cycle. Great rejoicing is made over the abolition of valves.

To the ordinary motor-car man a valve is a mushroom valve and this he is taught is a bad thing. It is curious that this should be so, for the gas engine was always held to have taken a new lease of life when its valves become mushrooms and the old slide valve dropped out. And the steam engine for highly superheated steam is not considered to be of any use unless it is fitted with valves of the mushroom order. And here is the last word in petrol engines with two shells and the long rubbing surfaces and it is welcomed because it is to cut out the mushroom.

So far standardized are motor cars today that practically there were but two innovations, in all that great space, since last year. One was this shell-valve system and the other was merely the adoption of the Joy valve motion to the steam engine of the White steam car. The engine, which is compound, has the cylinders brought very close together so that there is a stiff, short crank shaft by reason of the abolition of the eccentrics, rendered possible by the Joy gear. There was one other steam car in this big show besides the White (American) and the Turner (English) steam cars. This is the Rutherford. It does not seem a great number as a start for the eventual supremacy of the steam car which many, not without good reason, believe will occur. But it will need to move quickly, for motoring is not, I believe, so firmly established in certain directions as some people think. It is largely a flashy business, the sport of the wealthy, and very little more progress in the direction of the art of flying, as shown possible by the Wright brothers, may turn the craze for the last new thing in the direction of flying. Flying is an accomplished fact, and nothing is likely to prevent a very considerable advance during the next two years. Flying machines will become safer and anyone with room to house one and money to work it will be able to fly, with probably but little more risk, if so much, as when riding in a high-speed motor car.

In certain quarters the flying machine is regarded as all important for war purposes. It may be of some service—I would prefer the word disservice—in such a connection, but it will not be much good as a serious weight carrier and the day has gone by when a quick messenger would be valuable, for there is too much wireless about for that. Flying will be the hobby of the rich, and people who live by the roadside will welcome the change. There will be accidents at first, but chiefly to the riders themselves. But we are sorry to see so able a mechanician and engineer as one of the Wrights coming to hurt, for their achievement is very great. Not only have they solved the flying problem—they have shown that the machines can come to earth gently. This has dispersed the doubts of many who, while believing flight to be possible, had fears that the alighting problem was not so easy.

Recently the cylinder head of one of the engines in the Penn Mutual building, Boston, Mass., blew out and the flying pieces struck the other engine and "put it out of commission."

POWER AND THE ENGINEER

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More Frequent Internal Inspection

Because a steam boiler is covered by an insurance policy is no ground to believe that it is safe to operate for twelve months without an internal inspection. Nevertheless, this is a view held by some engineers and more steam-plant owners.

An insurance policy covering a boiler risk is a mighty good document for two reasons: it demands the payment of damage losses, and practically insures a safely operated boiler because of the inspection feature which accompanies it.

There is no need of going into the question as to what the inspection of boilers amounts to; it is already known. However, the importance of frequent inspection is, in most cases, greatly underrated, not only by the engineer, but also by the insurance companies, although one company at least is sitting up and taking notice of its desirability. The practice has been to make three inspections each year, two external and one internal. While the external inspections are efficient as far as they go, they do not reach the vital parts of the boiler.

There are hundreds of engineers who never know whether the safety valve and the steam gage operate together until the inspector makes his quarterly visit. This is because the engineer has no means of checking up his steam gage for accuracy. The fact that the lever of a ball-and-lever safety valve is marked 100 at a certain point is no assurance that the valve will blow off at 100 pounds gage pressure. The external inspection takes in these matters and is, therefore, of value, especially in the smaller plants; but the internal inspection is the kind that counts most for safety and economy.

One inspection company which formerly made a practice of making two external and one internal inspections yearly, now not only makes the same number of external inspections, but has adopted semi-yearly internal inspection instead of annual. Surprising as it may seem, the cost of repairing defective boilers under the old method of inspection exceeded the losses due to violent explosion, and these losses are confined to ruptures and not mere bagging which results from scale, oil, etc. The twice-a-year internal inspection has so reduced these lesser losses that the company has found that although it costs more to operate the inspection department, due to the increased duties of the inspectors, the saving made in avoiding expensive repairs amply compensates for the extra work and expense involved. The insurance company is not the only party benefited, as the steam-plant owner is, under this new system, doubly sure that his boilers are kept in good condition, regardless of the qualifications of his engineer.

What is sauce for the goose is sauce for the gander. If the making of two internal inspections is a paying proposition to the insurance company it is a good thing for the engineer. True, most engineers do not yearn for the task of inspecting boilers, but it is a duty that must be performed, and if properly carried out is a remunerative investment, not only in dollars and cents but in ease of mind.

A perusal of the reports of boiler-insurance companies for a year will present a startling array of facts, and the most significant of all is the faulty condition of boilers, due to scale, etc., which good management and frequent inspections would have prevented.

There will doubtless be some opposition on the part of the steam-plant owner against the so-called hardship of cutting out a boiler twice a year for internal inspection and while, to some, it may be time and money ill spent, to the great majority it means the saving of time and money spent in repairs, when of a nature not covered by the risk.

In the steam plant not covered by an insurance policy, nor under the jurisdiction of a State inspector, it is the duty of the engineer-in-charge to keep his boiler in a safe condition. He has to say whether the boiler shall be internally inspected twice a year or not. The responsibility is his.

Turbine Condensers

We present in this number, among our leading articles, an abstract of a paper on "Surface Condensation for Steam Turbines," by Professor Josse, director of the engineering department at the Technical High School at Charlottenburg. This paper has already been commented on in our correspondence columns and has excited considerable interest. The curve sheets and table have been converted into English measures and are of more than passing interest.

To manufacturers and users of condensers this paper is of especial value, giving as it does additional data regarding the transfer of heat through tubes from steam to water, supplementing the excellent work of Weighton, Stanton and Morison in England, Ser and Joule in France and Hepburn in America.

The investigation of the heat transference between air and water is put out in excellent shape for use, as is also the problem of taking care of the air leakage into the condenser. The details of the wet-vacuum pump, as illustrated, show a development of the suction-valveless air pump somewhat different from similar pumps in the United States, and the manner of introducing the noncondensable vapors to the barrel of the pump is new. The piston speed of this pump, 260 feet per minute, would be considered quite too high for good results in this country, necessitating very light valves and valve springs.

Professor Josse's condensers are small

compared with surface condensers for turbine work as we know them, and Weighton's experimental condensers were even smaller. It is unfortunate that none of the larger condensers, say from 5000 to 10,000, or even 15,000 square feet of surface, has been tested to the point where the vacuum fell off from lack of ability to condense the steam, as otherwise an opinion might be formed as to the value of the coefficient of heat transference U under the condition obtaining in surface condensers of commercial size for turbine work.

Professor Josse's statement that the surface-condenser outfit for turbine work may cost thirty to sixty per cent. of the cost of the whole turbine plant, which presumably applies to marine work in Germany, is more than surprising.

Loss in Alternating Current Wires

When electric current passes "through" a wire the passage involves two losses, one of pressure or voltage and the other of energy, the latter being the consequence of the former. If the current is of the "direct" class and reasonably steady in value, the proportion of the applied pressure used up in forcing the current through is exactly the same as the proportion of the applied energy wasted by the resistance of the wire. That is to say, if the "drop" in the circuit is ten per cent. of the applied voltage, ten per cent. of the applied energy will be lost in forcing the remaining ninety per cent. through the circuit; if the "drop" is two per cent., then two per cent. of the applied energy will be used up in overcoming the resistance of the circuit, and so on.

When the current is either an alternating or a rapidly pulsating direct current such as some of the early arc-lighting dynamos yielded, the percentage of energy loss rarely equals the percentage of pressure "drop" in the circuit. The lower the power factor of the complete circuit and load, the greater will be the difference between the percentage of energy loss and that of pressure "drop," because a low power factor is due to a counter-electromotive force generated in the windings of the load apparatus and self-induced by the current in the circuit wires. The farther apart are the wires of a circuit, the greater will be its self-induction and the lower its power factor.

The practical moral of the foregoing explanation is that alternating-current circuit wires should be located as close together as the pressure and insulation will permit, and that the percentage of energy loss in a motor circuit, which is easily figured, is no criterion of the voltage drop, which is *not* easily figured and has an important influence on the torque of an induction motor. The motor torque varies as the square of the voltage at the terminals of the machine; consequently, an excessive drop in voltage in the circuit wires may reduce the torque of a motor seriously.

Natural Resources

On Friday, January 22, the Government closed the presentation of its case against the anthracite railroads. The hearing will be resumed on February 16, in New York, when the defendants will open their side of the case.

The Government has offered in evidence a table of statistics showing that of the 76,000,000 tons of coal produced, only about twenty-one per cent. was produced by independent operators, and about two-thirds of this is in the hands of the railroads by contract.

Have we learned the lesson of the coalfields?

Who could have foreseen, when Col. George Shoemaker brought a load of the black-rock fuel into Philadelphia and nearly got into jail for trying to sell it, that in about one hundred years the transportation and industries of the country and the comfort and well-being of the people would come to depend upon it more than upon any other one factor? Who could have foreseen the enormous possibilities of a perpetual corner in anthracite coal, and with what derision would a forecast of the present situation and an appeal to forestall it have been met.

And yet we are passing through another period of absorption of public resources by private interests. The possibility of electrical transmission has endowed water powers hitherto of little or no value with great earning capacities. While there might have been some difficulty in establishing a governmental or communal ownership of the coalfields, the constitutions of most of the States and of the United States itself establish the right of the people to the use of natural streams. The people should be very guarded in surrendering that right, and we notice with pleasure that the President has vetoed several bills transferring the public holdings in such properties to private interests. This policy should not be continued to a point which will discourage needed development, but such grants when made should be so guarded and restricted as to secure the immediate development of the site as opposed to speculative holding, and the supply of power therefrom to the public at prices which will pay a fair profit upon the actual investment.

A few years will see a large proportion of the industrial power of this country generated by falling water. The increase from 1900 to 1905 was over thirteen per cent. Several States have appointed commissions to encourage and supervise its development. Without such supervision and restriction the power-using public is liable to find itself as completely in the grasp of a water trust as it is now in contributory vassalage to the coal barony.

Power from Niagara Limited

Although the ordinary discharge of the Niagara river is about 250,000 cubic feet per second, and it is estimated that by utilizing the total fall between the lakes 7,000,000 horsepower are available, or 4,000,000 at the falls, it has recently been decided by this country and Canada to limit the total amount of water used for power purposes. A treaty has been drafted to this effect and doubtless will soon be ratified. Agitation on this subject has been rife for some time and arguments on the side of the power companies, appeals from the lovers of natural splendor, views of the hotel men and transportation companies and, finally, the economic objections of the navigators on Lake Erie have all been given due consideration and the result has been to limit the total amount of water used by the power companies in Canada to 36,000 cubic feet per second and those on the American side to 20,000 cubic feet, it being the opinion of the engineers of the International Waterways Commission that this amount would not be detrimental to the scenic effect.

In the foregoing perhaps the navigators should have been given first place, for it is reported that every 22,000 cubic feet per second of water abstracted by the power companies lowers the level of Lake Erie by one foot. With large steamers engaged in the carrying trade each inch of draft represents a return of $100 in freight receipts, and for this reason probably more than any other the amount of water for power purposes was restricted to 36,000 cubic feet per second. The treaty expressly provides that the level of Lake Erie shall be maintained, allowing, of course, for the natural fluctuation of lake level.

During 1907 the mean discharge was 15,000 cubic feet per second above the average for fifteen years previous to January, 1905, and on April 27, 1908, the increase was 60,000 cubic feet per second.

From the power side of the question it would seem a hardship to limit the available supply of water to so small a percentage of the total, and at first sight it would appear to be sentimental extravagance on the part of Government employees. It must be considered, however, that visitors to Niagara number 600,000 to 1,200,000 annually and spend in transportation and at the falls as much as $25,000,000. A sum of this magnitude undoubtedly had its influence on the treaty, as did the claims of navigation interests. In a controversy of this kind it is impossible to suit all parties, but from every indication the treaty under consideration should come as near giving universal satisfaction as is possible.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Receiver Pressure Regulation for Compound Engines

In plants where low-pressure steam is used for heating or industrial purposes and where the amount of steam so used is less than the exhaust from the engines, it is often economy to use a compound engine, taking the low-pressure steam from the receiver. In such cases it is difficult by hand regulation of cutoff in the low-pressure cylinder to hold the receiver pressure constant, as the demand for steam or the load on the engine varies.

To secure this result, Charles T. Main, engineer, of 45 Milk street, Boston, Mass., has devised two forms of pressure regulator which have been installed in many plants on cross- and tandem-compound engines. The two types are used as best meets conditions. The advantages claimed to be secured are more uniform pressure in the receiver than is possible by any other means, thus giving a uniform steam supply, and saving of fuel by avoiding the blowing off of steam through relief valves or the supply of high-pressure steam to the receiver through reducing valves.

In Type A regulator, Fig. 1, there is a small cylinder C in which is a piston P, with the receiver pressure admitted to the cylinder below the piston. Above the piston the cylinder is open to the atmosphere. The piston rods R and R' connect with the arm A, and through this move the trip rods of the valve gear T and T'. To the rod R is connected the arm B and on this arm are hung two weights W and W'.

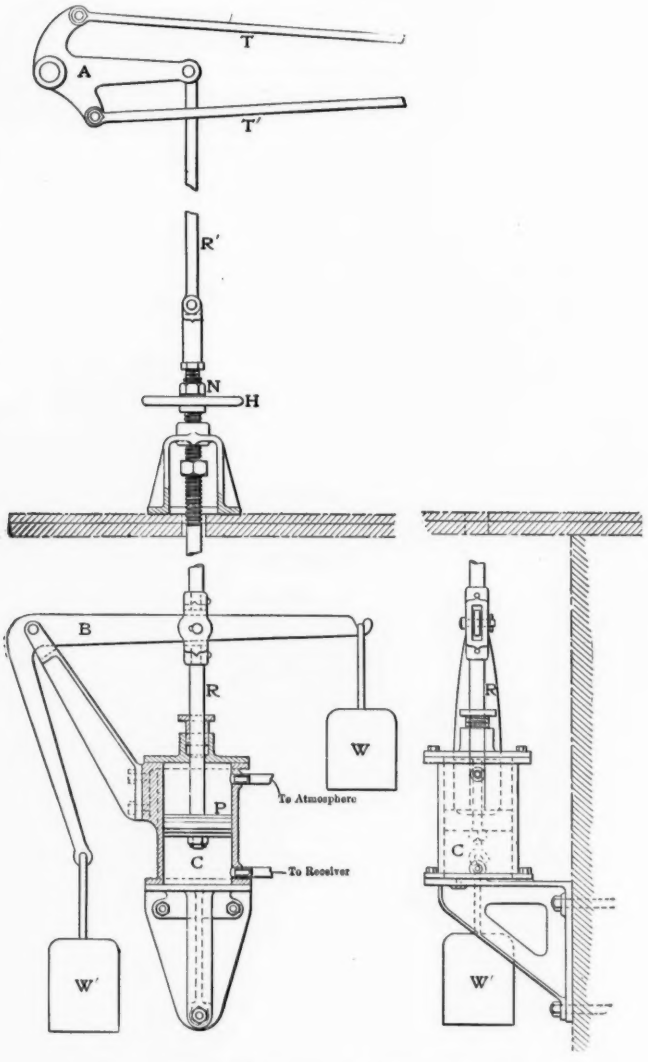


FIG. 1. TYPE "A" RECEIVER PRESSURE REGULATOR

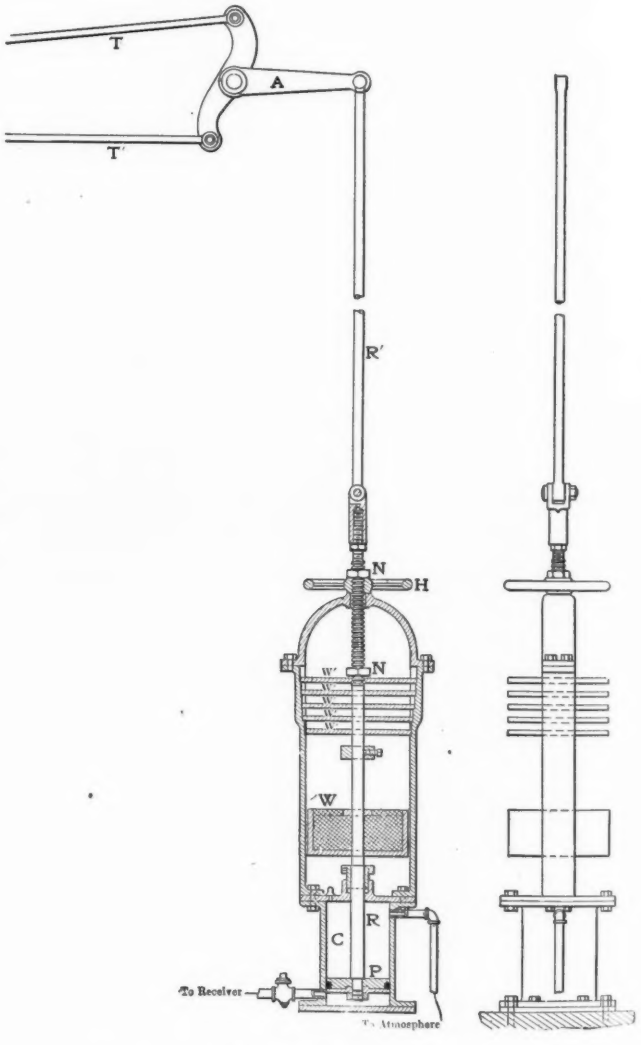


FIG. 2. TYPE "B" RECEIVER PRESSURE REGULATOR

When the pressure in the receiver increases, it raises the piston and increases the cutoff in the low-pressure cylinder; when the pressure falls, the weights bring down the piston, thus decreasing the cutoff in the low-pressure cylinder.

The weight W' determines the lowest pressure to be carried in the receiver.

and the weight W', as it swings from the vertical under pivot, balances the variable pressure from the shortest possible cut-off to full stroke on the low-pressure cylinder.

The hand-wheel H is used to get a long cutoff when starting up the engine, also to fix the minimum cutoff, or if desired to run with fixed cutoff. The nuts N and N' can be set to limit the range of cutoff.

Type B regulator works on the same principle, but has a series of weights W', which are lifted in turn as the rod R rises. The weight W determines the lowest receiver pressure and weights W' balance the variable pressure through the extreme range of cutoff.

A Novel Design of Indicator

We illustrate herewith a novel design of steam-engine indicator, the joint invention of George A. Mower, of 147 Queen Victoria street, London, and James F. Gill. In this device perforated diagrams are obtained, the perforations being produced by the passage through the paper of an electrical current.

The apparatus comprises a cylinder A, piston B and calibrated springs C, as in the ordinary type, but as it is only necessary that the piston shall move to a very small extent, the cylinder A is made correspondingly short. Fixed rigidly to the piston B is a light metallic rod or

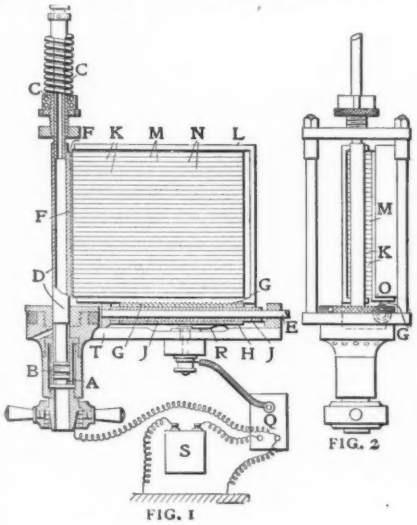


FIG. 2

FIG. 1

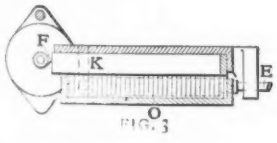


FIG. 3

tube D with a series of short teeth F forming electrical contact points at equal intervals along its length. The teeth F are formed integrally with the piston rod D.

The laminated plate K is mounted on the frame of the indicator in an electrically insulated case L, and is composed of a series of alternate strips of metal foil M and insulating material N. This laminated plate K is so disposed that the contact points F on the piston rod D just barely touch the edge of the laminated plate K. The series of metal-foil strips M is approximately the same in number as the contact points F on the piston rod D, but they are slightly differently pitched so that (as in a vernier scale) a limited movement of the piston will cause the

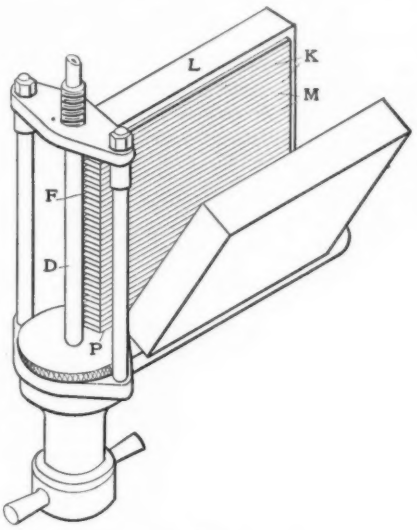


FIG. 4

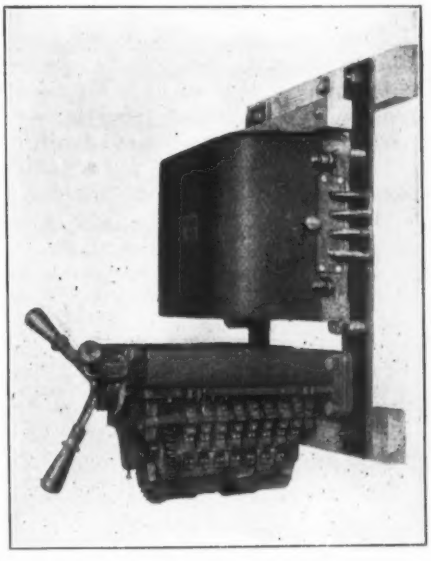
metal strips M to be electrified in succession; one of the series of contact points F making electrical contact with one of the series of metal-foil strips M, thus as the piston moves up through its limited amount of travel the point of electrical contact will move through a large range on the plate K.

A similar laminated plate O of approximately the same size as the plate K is secured thereto by means of a hinge P and spring, so that it lies on the plate K with its conductors all at right angles to those on the plate K. A second metallic rod E arranged at right angles to, and with contact points G similar to those on the piston rod D, but insulated from the frame T of the apparatus, is arranged to move through a limited distance and to make electrical contact with the metal-foil strips on the second plate. The contact points G are on a tube H insulated from the rod E by the ebonite or other non-conducting sleeve J. This second rod E is connected through suitable reducing gear to the piston of the engine to be indicated. An electric-sparking coil Q with a safety spark gap is connected so that the current therefrom passes through the spring R first to the tube H and contact points G on the second rod E, thence to one of the metal-foil strips in the second laminated plate O, according to the position of the engine piston, thence to a metal-foil strip M in the first laminated plate K and out through the contact F on the piston rod D and casing of the indicator apparatus to earth and back to the coil through the battery S.

To take a diagram: Open the apparatus as shown in Fig. 4; place a flat piece of any suitable paper between the two laminated plates K and O, secure them by the spring clip, attach the reducing gear to the piston of the engine, and turn on the indicator cock, switch on the electricity and the current will flow, and by disruptive sparking action will pierce holes in the paper which is the only impediment in the path of the current. The position of these small holes will correspond to the intersection of the two conductors at right angles which are electrified at the same instant, thus producing a diagram from which may be obtained a true record of the variations of pressure in the engine cylinder. If this perforated diagram is placed on a page of a book and an inked roller passed over it, the diagram will appear, its boundaries being defined by small dots.—*Mechanical Engineer.*

Wagner Induction Motor Starter

The accompanying engraving illustrates the type of starting apparatus built by the Wagner Electric Manufacturing Company, St. Louis, Mo., for use with squirrel-cage polyphase induction motors of more than 5 horsepower. The starter is of the autotransformer class, with the transformer inclosed in one iron case and the switch inclosed in another which is oil-filled. The transformer is provided with a number of sub-voltage taps giving different percentages of full voltage, and from which any desired tap may be selected for permanent wiring to the switch after one or two trials under actual service conditions.



WAGNER MOTOR STARTER WITH SWITCH EXPOSED

The switch, as will be noted from an inspection of the illustration is of the drum type, with a horizontal shaft; the oil-immersed mechanism is equipped with a quick-action make-and-break cam which reduces to the minimum the possibility of arcing between the working contacts. In

starting the motor the handle is moved always in the one direction. It may be turned back to the "off" position only from the first starting position; after once passing the first starting position it cannot be carried to the "off" position except by moving it through all of the succeeding positions.

In the " off" position the transformer and motor are both dead. Upon turning the operating handle into the first starting position the motor is connected to the sub-voltage tap of the transformer, with the fuses short-circuited; the connections thus established cause the compensator to deliver sufficient pressure to start the motor with minimum line disturbance. Turning the handle to the second position connects the motor to the full voltage and disconnects the autotransformer, the fuses being still short-circuited. Finally, in the third or full running position the fuses are cut into the circuit. This starter may be used in connection with any standard make of squirrel-cage motor. It is built for two- and three-phase work at any of the standard voltages.

Dinner to N. A. S. E. Officers

Friday evening, January 22, the Chicago Association of the N. A. S. E. gave a dinner to the officers of the national body at the Boston oyster house. The dinner was entirely informal, as it was arranged simply because of the officers' presence in Chicago on business connected with the association.

John F. McGrath, of No. 28, was master of ceremonies, and all the distinguished visitors were asked to say a few words to the assembled members and friends. The speakers were introduced in the following order: Fred J. Fisher, of Los Angeles, Cal., national president; Joseph F. Carney, of New York, past national president; WilliamJ. Reynolds, of Hoboken, N. J., national vice-president; Royal D. Tomlinson, of Milwaukee, past national president; John W. Lane, of Chicago, editor of *National Engineer*; John A. Kerby of Cincinnati, E. J. Lee of Albany, N. Y., J. H. Van Arsdale of St. Louis, W. W. McLane of Boston and Alfred Johnson of Chicago, trustees; F. W. Raven, of Chicago, national secretary. Nearly two hundred members participated in the enjoyment.

Hoboken Association No. 5, National Association of Stationary Engineers, will hold its annual entertainment and ball at Odd Fellows' hall, on February 9. The committee has prepared a first-class entertainment, and it is expected that the event will be up to the usual high standard.

Silk City Council No. 18 (Paterson, N. J.), Universal Craftsmen, Council of Engineers, will hold its annual entertainment and reception on February 12. A good time is assured.

Technical Education

By H. Addison Johnston

The trouble with the ordinary technical graduate is that when he gets his diploma, and can play three scales and "Home, Sweet Home" on the engineering piano with one finger, he thinks he is second only to Paderewski. He forgets, or rather he has never realized, that long experience in actual construction is necessary before he can safely and surely apply his mathematical theories to everyday work.

The engineering school does teach a man a whole lot about *how* to build engines, that it is very essential that he should know, but the only way to learn *to build* engines is to build engines. In this connection, hear the sad story of Jones:

Jones was a young, quite recent, technical graduate, and what he did not know about engineering was not worth knowing. Jones had not specialized particularly on thermodynamics, but he thought he knew something about it, and there is no doubt that he passed his examinations. Jones was great on accurate calculations; nothing worried him so much as leaving off the decimals; why, he could figure out the proper diameter of a staybolt to nine places of decimals and tell the probable error and all that. Jones was a very decent fellow, but one thing he hated, and that was to notice those awful, inaccurate, rule-of-thumb methods which prevailed in some shops. Why, in one shop Jones had visited, instead of having the last batch of bolt iron properly tested as to its elastic limit, ultimate tensile strength and resistance to shear, and calculating the allowable stresses and figuring a factor of safety, the superintendent had just casually remarked that he "guessed six five-eighth bolts would do for that there flange," and that was all there was about it. It was simply shocking that such practices were allowed in this scientific age.

Well, one day, at the club, Jones was comfortably explaining to the company the beautiful accuracy of scientific mathematical calculation as compared with the unreliable guesswork of cut-and-try schemes, when an acquaintance, Brown, by name, who was in the gas-engine business, asked him if he could give any simple, accurate. method of calculating the compression pressure in a gasolene-engine cylinder when the percentage of clearance was known.

"Why, certainly," said Jones, swallowing the bait whole, quite pleased at the opportunity to be of assistance. "The pressure of a gas varies inversely as the volume, 'Mariotte's law,' you know. Pressure multiplied by volume before compression equals pressure by volume after compression, like this," and he stepped to a small blackboard and wrote:

$$P_1 V_1 = P_2 V_2.$$

"Oh! I see," said Brown, who knew something of mathematics himself, even though he was a practical man. "Well, just for an example, what would a pressure gage show the compression to be on an engine with, say, 20 per cent. of the total cylinder volume as clearance?"

"That's easy," replied Jones. "The normal air pressure is 14.7 pounds, and we call the total volume 100; then the clearance will be 20." Then he laid out the following:

$$P_1 = 14.7. \quad V_1 = 100. \quad V_2 = 20.$$
$$P_1 V_1 = P_2 V_2. \quad P_2 = 73.5.$$

"There, that's it: 73.5 pounds compression."

"Must be something wrong," said Brown. "I saw an engine with 20 per cent. clearance tested and it had 110 pounds."

Jones checked over his figures. "Can't find anything wrong with the figures; must be the equation that's wrong. Um—um. Say! that equation is wrong. I have got the isothermal instead of the adiabatic equation. You see the air gets hot when it is compressed and that runs the pressure up. I should have written the equation this way:"

$$P_1 V_1^{1.41} = P_2 V_2^{1.41}.$$

"I guess this will bring it out about right."

Jones always carries a little table of logarithms in his pocket and pretty soon he said, rather dubiously: "That works out to 142 pounds compression; seems about as far out too high as the first one was too low."

"Well, put it on the board beside the other, anyway," said Brown. "After awhile we'll average them up. Looks to me, though, that you forgot to subtract 14.7 from your figure to get the gage pressure. You've got the absolute."

"Why, so I have," replied Jones. "Never thought of that; but, say, that first figure was too high by the same amount. It should have been only 58.8 pounds. The last one looks a little better now, though; 142 — 14.7 = 127 pounds compression gage. That engine you saw must have had leaks in it."

"No it didn't," said Brown. "But it strikes me the Prof. John Perry says that 1.41 is too high for air; 1.37 is the proper figure."

"Well, perhaps it is," said Jones, looking slightly worried. "I'll work it out."

Jones works out again:

$$P_1 V_1^{1.37} = P_2 V_2^{1.37}.$$
$$P_2 = 119$$

pounds gage.

"Getting closer," said Brown. "But that's too high yet; now I come to think of it, some other fellow says that 1.33 is the proper figure to use instead of 1.37."

Jones works out once more:

$$P_1 V_1^{1.33} = P_2 V_2^{1.33}.$$
$$P_2 = 111$$

pounds gage.

"There, that's right," he exclaimed. "Your pressure gage must have read a pound too low."

"Perhaps it did," replied Brown. "But seems to me that you have missed something. You see there is always a slight vacuum in a gas-engine cylinder at the end of the suction stroke. The piston moves out so fast that the air cannot get through the valve quick enough to keep up the pressure. I don't suppose the pressure would be over 14 pounds in some engines when the piston started on the compression stroke."

Jones said nothing, but worked it out with the new value for p_1:

$$P_1 V_1^{1.33} = P_2 V_2^{1.33}.$$

$P_1 = 14$ *pounds*; $\frac{V_1}{V_2} = \frac{100}{20}$ $P_2 = 106$ pounds gage.

"This is rotten," said Jones. "It's getting worse."

"We've only a few more left," said Brown. "Have you ever noticed that these mechanically operated inlet valves do not close until the piston has moved back about 5 per cent. of the compression stroke? You did not take that into account."

"Oh, well, I'll work it out a few times more," said Jones, crossly. "That 5 per cent. loss will just about have the effect of increasing the clearance to 21 per cent. instead of 20 per cent.

$$P_1 V_1^{1.31} = P_2 V_2^{1.31}.$$

$$P_2 = 14. \quad \frac{V_1}{V_2} \quad \frac{100}{21}.$$

$$P_2 = 97$$

pounds gage.

"Jones, there's another thing we did not take into account," said Brown. "There's a whole lot of hot exhaust gas in the cylinder that's going to warm up the charge and send the pressure up a little."

"Yes," snapped Jones, "and now you mention heat, I suppose the cold fresh charge will be warmed by contact with the warm cylinder walls, to begin with, and the hot compressed charge will be cooled by contact with the warm cylinder walls, to finish with, and little drops of gasolene will make some vapor and raise the pressure, and little leaks around the piston will lower the pressure, and if you know any more little variable constants or constantly varying variables, why spring them now."

"Cheer up," said Brown; "don't get worried. Just add up all the half decent results you've got and strike an average."

Jones worked out

$$\frac{127 + 119 + 111 + 106 + 97}{5} = 112$$

pounds gage.

"Just about right, eh?"

"Well, almost for the engine I saw," said Brown, getting up to go.

"Hold on!" cried Jones, "how the deuce do *you* figure your compression space to get the right pressure?"

"Well! I'll tell you," replied Brown, "though it's a secret and I wouldn't have it leak out for anything. When we get get out a new type of engine we open our mouth and shut our eyes and make a real good guess; then, if the pressure doesn't suit, we juggle the length of the connecting rod or the depth of the cylinder head until it does."

Alfred R. Wolff

We present herewith a likeness of the late Alfred R. Wolff, whose death, on January 7, was announced in the January 19 number. As previously stated, Mr. Wolff was one of the foremost heating

THE LATE ALFRED R. WOLFF

and ventilating engineers in the United States. He was a charter member of the American Society of Mechanical Engineers. In 1880 he started a general engineering practice at 38 Park Row, New York, removing in 1892 to 130 Fulton street. He took up the design of steam-boiler, heating and ventilating plants and established a practice which extended over a period of twenty-eight years. He was a member of the Engineers' Club. Mr. Wolff's practice as consulting engineer for steam-power, heating and ventilating installations has been taken over by Werner Nygren, Theodore S. Tenney and Arthur K. Ohmes, under the firm name of Nygren, Tenney & Ohmes, with offices in Rooms 907 to 916 Fulton building, corner of Fulton and Nassau streets, New York City.

Marine Engineers' Convention

The thirty-fourth annual convention of the National Marine Engineers' Beneficial Association was held at Washington, D. C., during the week beginning January 18, with headquarters at the Ebbitt house. There were about one hundred delegates in attendance. The reports showed the organization to be in a prosperous condition. The National Marine Engineers' Supplymen's Association, also in session at the Ebbitt house, entertained the delegates and guests during the week with trolley rides, theater parties, etc.

The leading social feature was a smoker held in the ballroom of the New Willard hotel, at which there was an attendance of about four hundred, including many Government officials. The entertainment was first-class in every particular, the entire company going from New York City especially for this occasion. On Wednesday afternoon the visitors were received by President Roosevelt, who was pleased at the meeting, and congratulated the members of the association upon their high standing in the engineering world. The President shook hands with each visitor.

On Thursday the following national officers were elected: W. F. Yates, president; J. J. Searey, first vice-president; W. P. Tindall, second vice-president; C. N. Vosburg, third vice-president; George A. Grubb, secretary; A. L. Jones, national treasurer; W. D. Blaicher, John A. Watts, F. J. Houghton, advisory board; A. J. Smith, trustee. The election of officers of the supplymen's association resulted as follows: Herbert Self, president; John W. Armour, vice-president; S. Inglis Leslie, secretary-treasurer.

Combined Associations, N. A. S. E.

The seventh annual entertainment and ball of the Combined Associations of the National Association of Stationary Engineers of Manhattan and the Bronx, New York, was held at the Grand Central Palace, Saturday evening, January 16. The attendance was larger than ever before. The hall was beautifully decorated with evergreen, floral and flag effects. An unusually fine vaudeville performance was given, after which the hall was cleared for dancing. There were delegations from Chicago, Pittsburg and many nearby cities, among them being all of the present and several of the past national officers, besides many other prominent engineers and supplymen. There were seventy of the leading engineering firms on the list of patrons.

The officers of the Combined Associations are: Fred Felderman, chairman; J. R. Coe, vice-chairman; W. M. Logan, treasurer; J. D. Taylor, secretary. The grand success of the event was due to the

combined, earnest efforts of the officers and the several committees, who deserved the hearty praise bestowed upon them.

Eccentric Firemen's Ball

The fourteenth annual entertainment and ball of the Eccentric Association of Firemen, Local No. 56, I. B. of S. F., of New York, was held at Grand Central Palace on Saturday evening, January 23. The large and prettily decorated hall was filled to its capacity. A vaudeville performance preceded a long dancing program, and goodby's were said after a most enjoyable night. This event always attracts many people prominent in the engineering world, and besides these there were present a number of distinguished guests, including J. Pierpont Morgan and daughters, William K. Vanderbilt, Postmaster E. M. Morgan and wife and Lewis Nixon.

Business Items

Schuchardt & Schutte have removed their New York offices and warerooms from 136 Liberty street to the West Street building, 90 West street.

Arthur Hoyt Bogue has resigned as general manager of the Atlas Preservative Company of America and has opened an office as manufacturers' direct representative at 142 Pearl street, New York.

Jersey City Association No. 1, N. A. S. E., wishes to get manufacturers' catalogs, samples, etc., for its meeting room. Such catalogs should be sent to John T. McEntee, secretary, 295 Third street, Jersey City, N. J.

John P. Cosgro, who during the past few years has spent considerable time in the southwestern part of this country and the northern States of Mexico, has been appointed district manager of the Allis-Chalmers Company, with offices in the El Paso & Southwestern building, El Paso, Tex.

Henry I. Lea, who has been associated with the Emerson McMillin and the Dawes syndicates, the Western Gas Construction Company and the Westinghouse Machine Company, has opened an office in Room 616, The Rookery, Chicago, Ill., as gas engineer. He will design, construct or manage gas works and make examinations and reports.

Cyrl J. Atkinson, designer of the Atkinson gas producer, which has been manufactured by the Industrial Gas Power Company, lately severed his connection with that company, and is now located with the Dornfeld-Kunert Company, of Watertown, Wis., which is building under his management and supervision improved forms of his gas producer, both of the suction and pressure types.

The copartnership heretofore existing between Frank B. Williams and George H. Williams, doing business under the firm name of I. B. Williams & Sons, Dover, N. H., has been dissolved by mutual consent, George H. Williams retiring. The business, that of making leather belting, will be carried on in future under the same firm name by Frank B. Williams, who assumes all outstanding obligations.

The Minneapolis Steel and Machinery Company has been given the contract for furnishing the new engine for elevator "D" of the Consolidated Elevator Company, Duluth, Minn. They will install a 26- and 52- by 48-inch vertical tandem compound Twin City Corliss engine, with flywheel 16 feet in diameter grooved for twenty-two 2-inch ropes. The entire engine will be completed by April.

The National Tube Company has just issued a handsome pamphlet under the title of "Shelby Steel Tubes and Their Making." After a brief review of the history of the art, the seamless process is described step by step, illustrated by numerous half-tone reproductions of photographs of the processes and the product in the various stages. It is beautifully printed upon heavy plate paper and will make an attractive and interesting addition to the library of an engineer.

Edward C. Brown, manager of the Hawaiian office of the Dearborn Drug and Chemical Works, at 42 Queen street, Honolulu, is making an extensive oriental trip of three or four months, during which he will visit Japan, the important seacoast cities of China, Australia, the Philippines, Java and other important islands in the Pacific ocean. Mr. Brown has most successfully handled the Dearborn company's business in the Hawaiian islands since that department was opened some ten years ago.

The Lagonda Manufacturing Company is distributing an interesting booklet of twenty-four pages on "The Scale Question." The booklet gives numerous facts about steam-power plant economy and protection and will interest all who own or have charge of boilers, economizers, condensers, etc. Among the new Lagonda products described therein is the Weinland air-driven wing-head cleaner. This machine is a miniature rotary engine which goes into the tube and rotates the cleaning head in much the same manner as a turbine does, but is claimed to be more powerful. The booklet will be sent to all who write to the Lagonda Manufacturing Company, Springfield, O.

New Equipment

It is said the McCook (Neb.) Electric Light Company is planning to rebuild its plant.

The Mammoth Spring (Ark.) Electric Light Company will rebuild its burned plant.

E. C. Bowman, Birmingham, Ala., contemplates the construction of a cold-storage plant.

The Houston (Tex.) Electric Company is planning the installation of additional equipment.

The Carthage (N. Y.) Electric Light and Power Company is planning to install another generator.

The citizens of Glasgow, Mont., voted to issue $50,000 bonds for water works. J. J. Mullins, town clerk.

The Ocala (Fla.) Ice and Packing Company will increase the capacity of its ice and cold-storage plant.

G. W. Cavanah, town clerk, Sebree, Ky., will receive bids until Feb. 15 for constructing water-works system.

J. Fletcher, owner of the electric-light plant at Wolsey, S. D., contemplates installing a new engine and generator.

The Ennis (Tex.) Ice, Light and Power Company contemplates installing a 200-horsepower boiler and engine.

The Valley Electric Company, New Brighton, Penn., is planning the installation of a 500-kilowatt turbine unit.

A new electric-light plant is to be built at the De Pauw University, Greencastle, Ind. R. L. O'Hara is president of board of trustees.

The City Council, Barberton, Ohio, is said to be considering the purchase of a new air compressor for the water-works plant, to cost about $3000.

The Lincoln (Ill.) Railway and Light Company has under consideration the question of installing a steam-heating plant using exhaust steam.

It is reported that a new dynamo and engine will be installed in the Municipal electric-light plant at Quincy, Fla. B. A. Puckett is manager.

The Skagit River Power Company, Denver, Colo., has completed plans for the construction of a 100,000-horsepower plant. E. M. Riggs is president.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

SALESMAN WANTED—Young man experienced in selling mechanical draft apparatus in New York City and vicinity. Box 93, POWER.

WANTED—Technically educated draftsman on general line of boiler shop drawings; must be speedy and experienced in this particular line of work. Box 92, POWER.

FUEL COMBUSTION — Important firm handling well introduced special fuel combustion apparatus desires local representatives in New York (Buffalo section), northern Ohio, Minnesota, Iowa and Colorado. Full particulars to "Fuel Experts," Box 87, POWER.

WANTED—A good live agent in every shop or factory in the U. S. to sell one of the best known preparations for removing grease and grime from the hands without injury to the skin. Absolutely guaranteed. An agent can make from $5.00 to $25.00 over and above his regular salary. This is no fake. Write for free sample and agents' terms. The Klenzola Co., Erie, Pa.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

SALESMAN, technical graduate, 29, selling and engineering experience in gas and steam engines, motors and other power machinery, wants position. Box 90, POWER.

HAVE PASSED steam engineering correspondence course and taken two months' shop work at Highland Park College, Des Moines, Iowa. Would like employment as engineer in small stationary plant or fireman in large plant. Box 94, POWER.

POSITION WANTED as chief engineer; experienced with all kinds of engines, steam turbines, a.c. and d.c. generators, motors and switchboards, boilers and pumps. I can get results and furnish the references; have been seventeen years in the mechanical and engineering business. Box 9, POWER.

CHIEF ENGINEER, experienced with compression ice plants, Corliss, turbine and gas engines in central stations, desires to make a change to any kind of plant. At present operating a central station containing two makes of turbines, compound condensing Corliss engines, and a.c. and d.c. generators. Box 91, POWER.

POSITION WANTED by a thoroughly competent and practical engineer. Long experience in erecting, installing and operating steam, water and electric power plants; capable of taking full charge of any plant. Am now holding good position under first class Massachusetts license, but desire to change. Best of references on application. Box 77, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

MACHINERY built to order; up-to-date plant. Write Brunswick Refrigerating Co., New Brunswick, N. J.

IF YOU DESIRE to learn the latest im-

A Low-Head Hydroelectric Development

An Interesting Plant at Milford, Maine, to Develop 12,000 Horsepower under a Head of 20 Feet, and Generate Three-phase 2200-volt Current

B Y S. R I C E

Low-head water-power developments are, as a class, of much greater importance to the country than those of any other type, both because of their numerical superiority and from the fact that the conditions which render them possible are more frequently met with near large manufacturing centers, where the current generated may be used, than are conditions necessary to high or medium heads, which require the vicinity of mountains, hills or unusual geological formations such as exist at Niagara.

At Milford, Me., there has been placed in successful operation one of the most interesting of the low-head power developments to be met with anywhere in the United States. The source of power is the Penobscot river, which flows in a group of lakes in Piscataquis county, not far from the Canadian border, and flows in a general southeasterly direction to Penobscot bay, draining in its upper reaches a territory of about 8000 square miles.

FIG. 1. THE DAM AND POWER HOUSE AT MILFORD

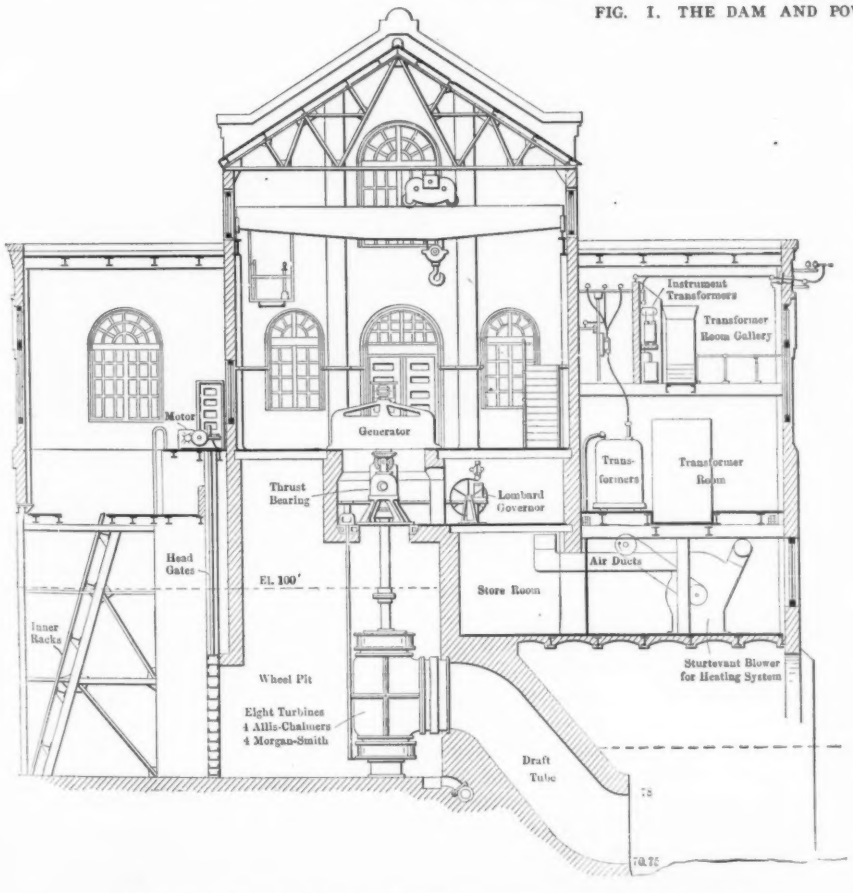


FIG. 2. SECTION OF POWER HOUSE THROUGH TRANSFORMER ROOM

Near Millinockett, about 150 miles up the river from Milford, the Great Northern Paper Company has constructed a dam, where about 10,000 horsepower is developed under a 110-foot head and used to operate electric generators to supply current for motor drive throughout the company's mills. The various reservoirs made by damming the Penobscot river at this point create storage for about 26,000,000,000 cubic feet of water, and the Great Northern Paper Company is under contract with the governmental authorities to let down a minimum of 2000 cubic feet of water per second.

South of Millinockett the highest head of water is found at Milford, where the total fall of the river from its source, as shown by the U. S. Geological Survey, is approximately 1000 feet, and there the Bodwell Water Power Company has built a plant to develop 12,000 horsepower under the normal working head of 20 feet. The immediate cause of erecting a central power station at this point was the opportunity to contract at once for 3000 horsepower to be furnished the Eastern Manufacturing Company located at South Brewer, about 17 miles distant; but there are quite a number of paper mills and

other industrial establishments in the vicinity of Milford, and the manufacturing city of Bangor is situated on the river 10 miles below; so that there was every prospect of being able to dispose continuously of the full available quantity of current, and this expectation has been realized.

Across the river from Milford, in the vicinity of Old Town, are two woolen mills and a pulp mill, water for which is taken from the river through a canal discharging below the new dam; but the amount of power diverted by this means is not enough seriously to affect the Bodwell company's project.

Concrete Dam

The dam built by that company extends 1000 feet from the new power house to the abutments of the canal above mentioned on the western side of the river. This is of solid concrete construction, 12 feet wide on the crest and varying from 14 to 32 feet at the base. This latter difference is accounted for by the irregularity of the bed of the stream, necessitating stronger and wider foundations in its deeper parts. The spillway extends the entire length of the dam, and there are no openings with the exception of a 25-foot log sluice next to the power house and adjoining the dam on the eastern side and a fishway 30 feet at the bottom and 10 feet at the top, which extends between the log sluice and the power house. These are controlled by steel gates, motor-operated.

Power House

The power house is located at the easterly end of the dam on the Milford side, being constructed of concrete as far as the generator floor and having brick walls above that level. It has a length of 225 feet 10 inches and a width of 84 feet 8 inches and is divided into three main parts. The central part, with pitch roof, contains the hydraulic turbines and governors and the electric generators; the up-stream aisle contains the rack and flume gates and the down-stream aisle houses the auxiliary electrical machinery and other apparatus.

Up to elevation 115, which is 15 feet above the crest of the dam, or datum, the foundations and walls are of concrete. All walls above this elevation are of brick surrounding a steel frame. There are two sets of racks, outer and inner, the former being placed a short distance up stream from the power house. These are built of structural-steel frames, securely braced, and extend 6 to 7 feet above the crest of the dam. The general construction is clearly shown in the side elevations of the power house. The steel gates are motor-operated. All of the rigging is so arranged that there are no gears or other appliances liable to be clogged or have their operation interfered with by ice or other débris that may be carried through the racks. Water enters to each turbine through a separate flume, the walls of which are of concrete reinforced with steel. Discharge is directly into the river below the dam.

FIG. 3. THE GENERATORS AND EXCITER UNIT

The Turbines

The hydraulic turbines are built for operating at their best efficiency under a head of 20 feet and a speed of 150 revolutions per minute. Under these conditions the flow of water through each is at the rate of 483 cubic feet per second, with delivery of 875 horsepower. Each turbine has two 45-inch runners of the Francis type, mounted on a heavy vertical shaft and with central discharge casing connected to a draft tube built of reinforced concrete. Every portion is easy of access

for inspection and repairs. The water flow is regulated by movable vanes, operated by vertical shafts and levers from the piston of an oil-pressure governor.

The head under which these turbines run will be increased, perhaps as much as 5 feet, by the raising of the head water, and it is also expected farther to increase the head by improvements in the river below the power plant, bringing the tail

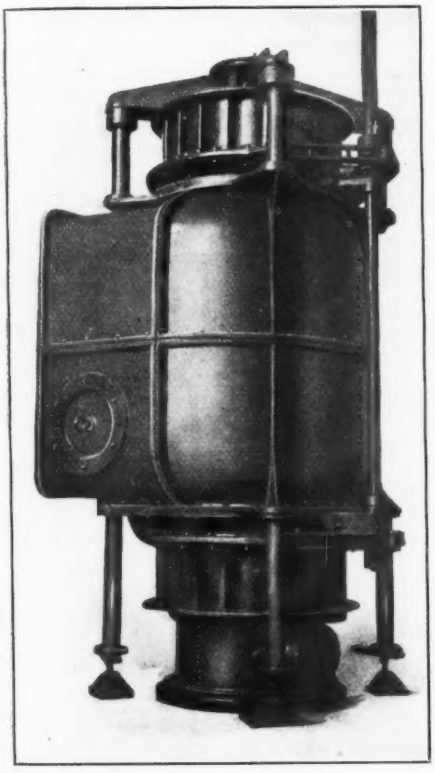


FIG. 4. ONE OF THE ALLIS-CHALMERS TWIN TURBINES

water down nearly or quite to the top of the outlet of the draft tubes and making the ordinary working head from 25 to 27 feet. The dam was built heavy enough to have the required hight added, and grooves were left in the top of the structure for bonding. The wheels are built for operating at their best efficiency under a head of 20 feet at the speed above noted; but with a head of 25 feet the percentage of efficiency will not be materially reduced. Under a 14-foot head normal speed is also maintained and the output is relatively high. All parts are so proportioned that, when running under the full contemplated head of 27 feet, the machine will stand the operating stresses within a liberal factor of safety.

As a water power is of highest economy when the energy developed from the natural resources available is the largest under all operating conditions, a lowering of 6 inches, or 30 per cent., of the available head will cause serious reduction of the capacity of the plant, if the turbines are not designed with careful consideration of such conditions. The speed of the 875-horsepower units being specified as 150 revolutions per minute, this must also be maintained at the low head of 14 feet caused by backwater in the river at time of flood, and it is here that the turbines should develop as much power as possible.

While it is not difficult to design a turbine to meet the requirements of speed and power at 20 feet and at the same time show a good efficiency, it calls for more than ordinary engineering skill also to obtain satisfactory results under the reduced head of 14 feet. It must be borne in mind that when tests are conducted in the flume at Holyoke to prove the efficiency of the turbine, such tests have to be made at a head which does not vary much. It is, therefore, an easy task to design a runner which shows up nicely at Holyoke, while it is questionable whether such a runner will give in operation a result which is the most satisfactory commercially. Many engineers believe that they secure a high-grade wheel when they note on the test sheet that the efficiency exceeds 80 per cent., and quite often this very turbine will not be as good an earner of money in the plant as another one which probably showed less efficiency at Holyoke, but was designed to be better adapted for the commercial-operating conditions. From this point of view the special turbines at Milford were designed, and it is not surprising that their performance has given satisfaction and an unusually high efficiency obtained.

Between each turbine and generator, in the basement above the wheel, is a thrust bearing carried by a cast-iron base ring grouted into the concrete arch over the turbine pit at elevation 107. Each of the bearings originally used with the first of the units to be installed consisted of two cast-iron disks with an annular groove to which oil was supplied at 225 pounds pressure. This made an excellent bearing, but was expensive to maintain and entailed too great risk in operation; as an accident or wrong manipulation by an operator, resulting in derangement of the mechanism, might not only cause the pressure to drop or be lost entirely, but would cause every unit running at the time to be put out of commission, entirely ruining the disks the moment they came in contact and tying up the plant most effectually until each unit had been dismantled and the defect repaired.

After a brief operating experience, during which disaster was several times avoided by a close margin, it was decided to equip all of the units in the station with oil-bath bearings, which, being self-contained and floating in oil, not only require very little attention and no auxiliary apparatus and consequently reduce the number of operatives necessary, but also eliminate any danger from a sudden shutdown, and effect a saving of over $6000 per year in oil. On starting up the first unit with which the new oil-bath bearing was equipped, full load was put on the machine within a few minutes' time, and the unit has been in continuous operation ever since, at decreased temperature, with no change of oil.

For each of the turbines in this station there has been provided a vertical oil-pressure governor, so arranged as to be visible either from the switchboard or any portion of the main floor. These governors can be controlled by electric-switchboard connection, automatic regulation by flyballs or hand regulation. They are driven from the wheel shafts through bevel gears, shafting and link belting. Each governor is cylindrical in form and made up of two chambers, the upper being an oil and the lower a pressure chamber; the latter has an oil gage and a pressure gage, so that the volume of air and oil and existing pressure are always in plain view, and it is provided with an adjustable safety valve. Between the two chambers lies a horizontal differential cylinder, the piston of which is directly connected to the regulating shaft.

The oil pump is of the rotary type and placed in the oil reservoir. It is self-lubricating and is connected by a shaft, projecting through the casing, directly with the turbine. The chain which forms a part of the connecting mechanism is easily detached. The flyballs, which are designed as a sensitive but absolutely static apparatus, are tested and carefully adjusted to the required percentage of change in speed. They are driven by

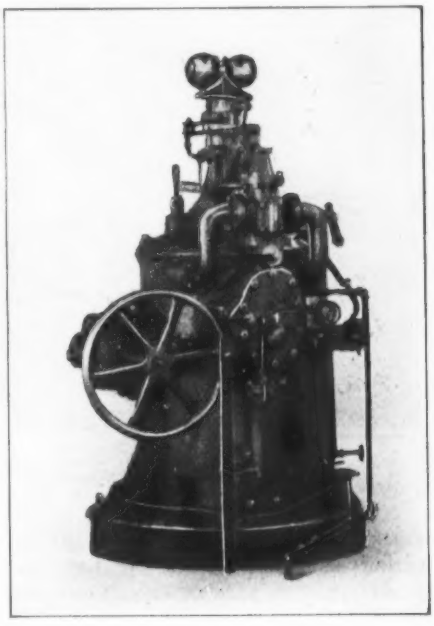


FIG. 5. ALLIS-CHALMERS GOVERNOR

means of a bevel gear located in the oil reservoir and can be started or stopped by means of a friction-clutch coupling without stopping the pump. The regulating valve is not rigidly connected to the floating lever of the flyballs, but is balanced.

GENERATING EQUIPMENT

The generator room extends full length

of the power plant and is 36 feet wide. Room is provided for 12 alternating-current generator units of 750 kilowatts capacity each and one 300-kilowatt exciter unit, the distance between units being 16 feet. Another exciter of 200 kilowatts capacity is driven by a three-phase, 2200-volt induction motor and placed below the switchboard gallery in the same bay.

The generators are of the revolving-field type, three-phase, 25 cycles, delivering current at a terminal pressure of 2200 volts. Excitation is 120-180 amperes at 125 volts. The switchboard is of blue Vermont marble and located in a gallery 15 feet above the floor. It consists of the usual complement of generator, feeder and exciter panels and special regulator and auxiliary-circuit panels. For all 2200-volt connections oil switches are used. They are located in concrete cells on the thrust-bearing floor directly underneath the switchboard. The power transformers, designed to step up from 2200 to 22,000 volts, are placed in the basement of the south bay, and in the room above are two banks of instrument transformers. The station is served by a 25-ton Niles crane, electrically operated, and is heated by the blower system, a motor-driven Sturtevant blower being placed in a subbasement under the transformers.

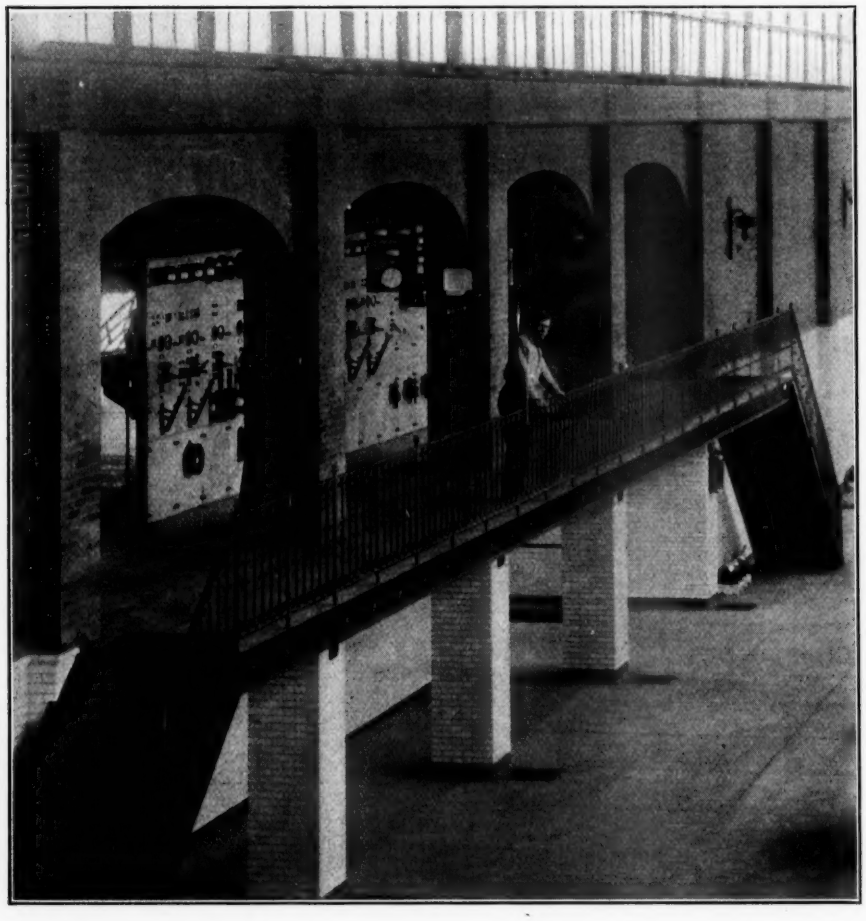


FIG. 6. SWITCHBOARD GALLERY

Miscellaneous Improvements

By W. H. Wakeman

Fig. 1 illustrates the governor of a Putnam engine, with its substitute for a dashpot, which is designed as follows: The column of this governor is hollow and contains a rod which connects the inner ends of the fly-ball arm to the hollow casting *A* that is pivoted to the lever *B* and is carried by a shaft, one end of which rests in the bearing *C*. The cap on this bearing is lined with leather instead of babbitt metal, and it is held in place and clamped on the shaft by one cap screw. When the governor balls rise, *A* falls, and *vice versa*, thus causing the shaft to turn slightly in the bearing *C*. As it does not move freely it offers resistance to rapid changes in the position of the governor balls; therefore, it is a very good substitute for a dashpot.

The leather lining is durable but, of course, it wears slowly, and when it becomes too loose the engine races. To remedy this defect it is only necessary to tighten the cap screw. One day this engine raced when starting up, which was very unusual, and applying the natural remedy made no improvement because the cap was what would be called "brass bound," if it were on the crank pin of an engine; therefore, it could not be tightened until repaired. To turn out the cap screw, remove the cap and take out the leather lining was a short job, and as it would take several minutes to fit a new leather lining into place, a piece of writing paper was fitted into the cap and the leather put back. This was sufficient to give the cap a hold on the shaft, and provided enough friction to control the governor perfectly. The advantages of this method are that it required less than five minutes to do the job, and the perfect fit of the leather on the shaft was not disturbed. From present indications it will probably last a year.

The two pump governors shown in Fig. 2 are designed for 1½-inch pipe. The vertical central pipe is 2 inches, with a cross at its terminal, into each horizontal outlet of which a 1½-inch nipple was screwed, followed by a valve as shown. The connection between this valve and the pump governor on each side was originally 1½ inches, but proved to be too large for smooth running under existing conditions. A sediment catcher is located below the cross, also a trap for removing the water of condensation.

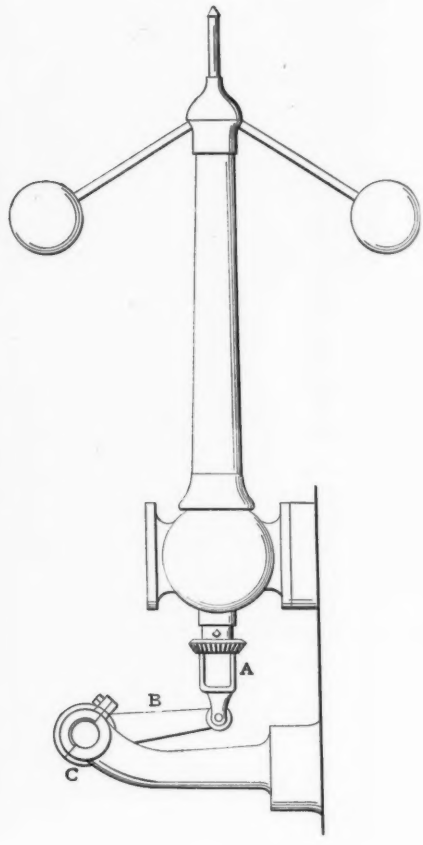


FIG. 1

These governors control two duplex pumps, with 7½-inch steam pistons and 6-inch water cylinders, taking water under 20 pounds pressure and raising it to 45

pounds. As the area of a 6-inch circle is 28 square inches, and the actual pressure per square inch to be overcome by steam pressure is

$$45 - 20 = 25$$

pounds, the total resistance exclusive of friction is 700 pounds. The area of a 7½-inch circle is 44 square inches; therefore, it requires

$$700 \div 44 = 16$$

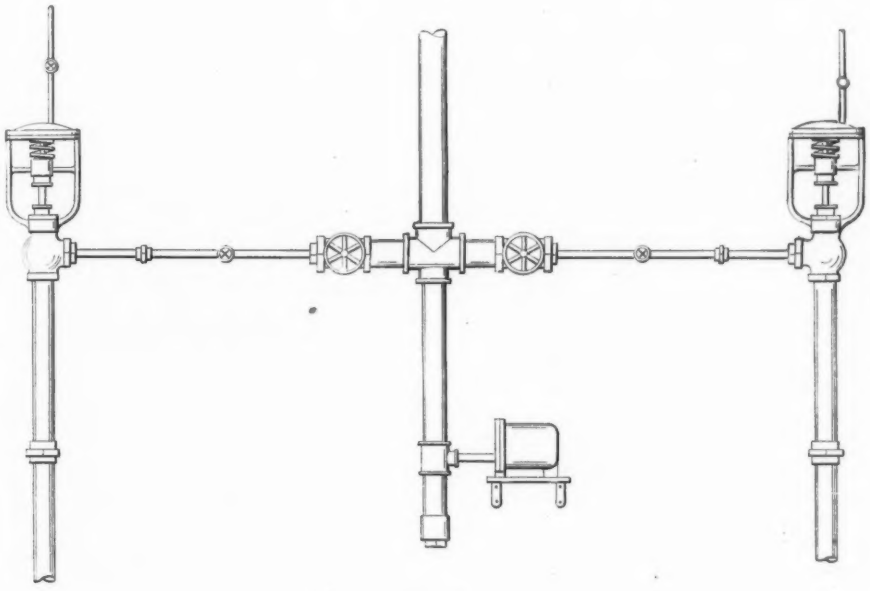


FIG. 2

pounds steam pressure to balance the load, which must be increased in order to give the required speed, but even then only a light pressure is sufficient to do the work.

Fig. 3 illustrates this point, as there is a water pressure of 20 pounds acting on the water piston, which tends to force it through each stroke, while the pressure on the opposite side is 45 pounds; therefore, only the difference is to be provided for. If the steam pistons of these pumps were 6 inches in diameter, the required pressure would be 25 pounds, and if they were only 5 inches it would be 37 pounds, which is about one-half of the boiler pressure. This would be more satisfactory for service in general, and for this case in particular. Only drip cocks are provided for the steam cylinder of each pump, and there is no drip pipe for the frame.

The 1½-inch pipe between the cross on one side and a governor on the other was taken out, bushings which reduced the openings to the right size for ½-inch pipe were substituted and a suitable connection as shown was made for one pump. The service rendered proved to be so much better that a similar change for the other soon followed, and both are now giving satisfaction. The reason for this is that when a large quantity of water was used, causing a sudden reduction of pressure, the governors responded quickly, giving a full charge of steam to the cylinders, as the pipe was large enough to supply the necessary quantity. The result was noisy operation that could not be tolerated in that place.

The governors respond now as readily as before the steam pipes were reduced, because they depend on the water pressure, but the quantity of steam that can be admitted in a given time is much less than formerly; therefore, the pistons do not start quickly enough to cause pounding in the water cylinders and pipes, yet the pressure does not fall enough to be objectionable.

A 6x4x6-inch duplex pump in my plant takes hot water under no pressure and delivers it against 80 pounds pressure. The steam is supplied through a ⅜-inch pipe. It is possible to secure the same results where pipes and valves of regulation size are used, provided the supply of steam is carefully throttled, but it is not practical under average conditions.

Fig. 4 is the steam end of a direct-acting pump fitted with a single-connection sight-feed lubricator, which is a great improvement over the brass monstrosities, found on many of these pumps, which are by courtesy called "lubricators." In many cases the drip cocks from these pumps are not piped to the sewer; therefore, when the fireman opens them, steam, oil and water are blown out on the boiler-room floor. This is poor practice and ought to be discontinued. No drip cocks are used on the pump shown, but angle valves are provided and the pipes are carried far enough away to admit of opening and closing them without inconvenience. The frame is made in the form of a trough in order to receive oil and water that fall from the stuffing boxes. In this plant nearly all drip pipes in the engine and boiler rooms discharge into one pipe that empties into the sewer; consequently, when water was blown out of the steam pipe it backed up into the frame of this pump and usually made a dirty mess on the floor. Of course, the globe valve shown could be closed, but this caused water to collect in the frame until it overflowed. This was the case before the check valve was added lower down, but since this improvement was made there has been no trouble from this source. A check valve should always be located low enough to allow at least 8 inches of water to collect above it without remaining in the part to be drained.

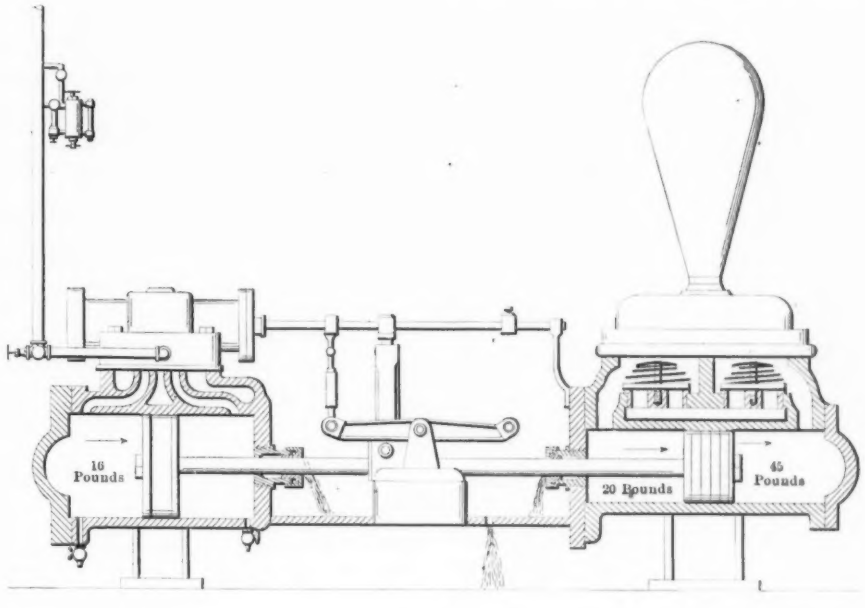


FIG. 3

Fig. 5 illustrates a damper regulator operated by water pressure in the usual way. The overflow pipe was connected into the system of drip pipes mentioned in connection with Fig. 4. There was a check valve in this pipe to prevent water from being forced back into the overflow, but it was located under the floor in a

small space with other valves and several pipes, making it inaccessible for cleaning and repairs. The overflow pipe was originally of small size and made as short as possible, with few fittings. Air would sometimes be trapped in this pipe, and thus prevent water from flowing away freely, causing it to spill on the floor and cause trouble. To prevent this action the pipe was increased from ⅜ to 1 inch, and a tee used in place of the first ell, as shown under the main lever. As the upper outlet was left open the air escaped freely, yet the water did not overflow, because the tee was as high as the small reservoir provided.

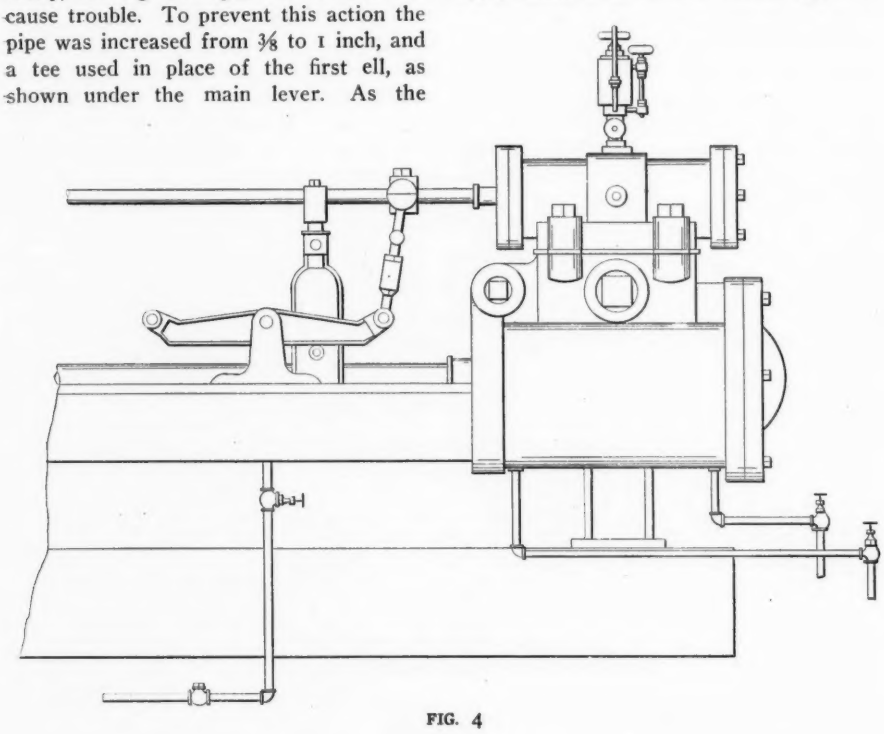


FIG. 4

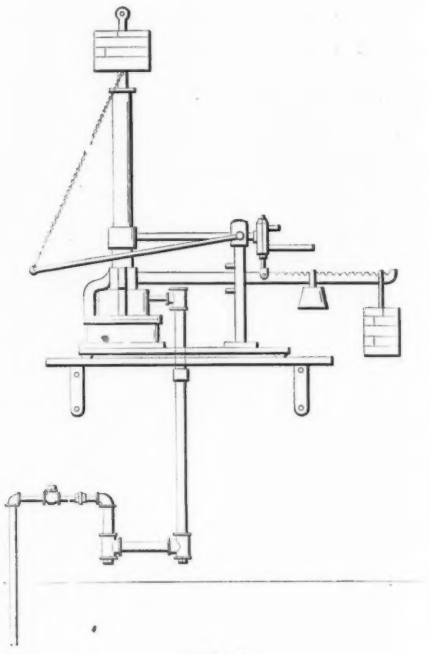


FIG. 5

The original small pipe became filled with sediment from the water used, at a point beneath the floor, but this objection was removed by making a pocket above the floor, using 1-inch tees and suitable nipples for this purpose. Two plugs were provided, the threads coated with graphite, and they were screwed in only lightly in order that they may be easily removed when the trap thus formed becomes filled with sediment. These are located high enough to admit of setting a pan under them to prevent staining the floor with muddy water when the pipe is washed out.

Fig. 6 illustrates a tilting steam trap located where it receives the discharge from three long drip pipes, which discharge water from different parts of a heating system. Sometimes this part of the system is noisy because the water resulting from the condensation of steam is warm in one drip pipe and cold in another; therefore, one kind of water hammer is the result. By throttling the discharge from the warm pipe, for which a valve is provided, this can be prevented, as it regulates the flow until there is little difference in the temperature of the pipes, resulting in smooth operation.

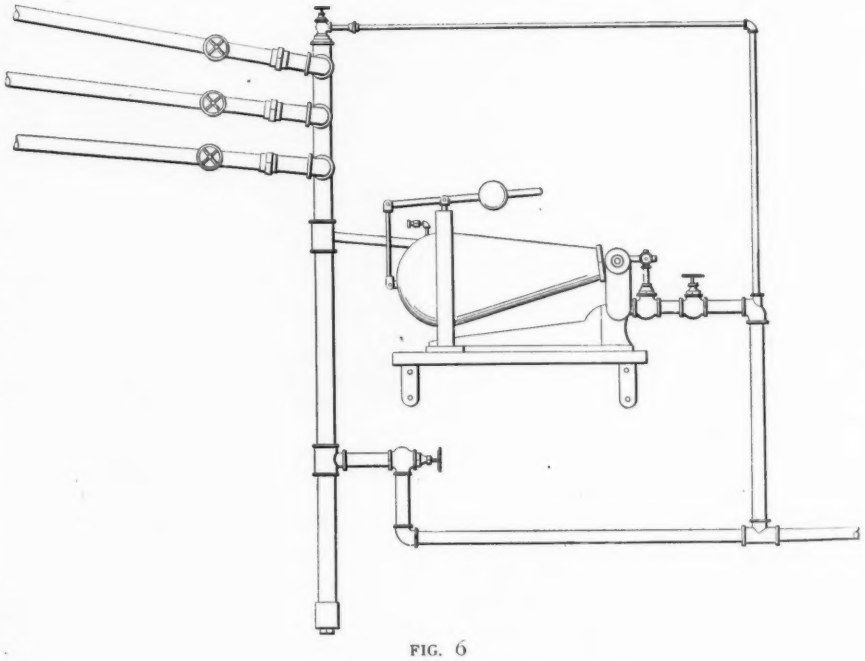


FIG. 6

These three pipes discharge into a vertical header, on the top of which is a ⅜-inch angle valve that is opened one-sixth of a turn. This allows all air to escape to the return pipe, preventing excessive pounding, even when steam is first turned on, and keeping the pipes free from air at all other times; but it does not waste heat, because the return pipe is about 400 feet long, which is sufficient to allow the returning water to become cool; therefore, the small amount of steam that passes this valve, usually under 3 pounds pressure, goes into the feed water and gives it a higher temperature than it would otherwise have.

The outlet from this vertical header to the trap is connected just below the lower inlet, while the bypass, or blowoff valve, is of the angle type, located lower down, with a dead end or pocket still lower, formed of the same pipe; consequently, if the incoming water contains sand, scale from the inside of the pipes and other foreign matter, it will lodge in this pocket instead of going into the trap. When pressure is off from the heating system, a plug at the lower extremity is unscrewed and all sediment removed. It is surprising to note how quickly such a pocket will fill with sediment. This arrangement of drip pipes, etc., was devised to take the place of connections that did not give good results on account of poor design and inconvenient operation.

Modern British High-Speed Steam Engines

Current British Practice, Giving Efficiencies, Methods of Governing and Lubrication and Principal Details of Standard Makes

BY JOHN DAVIDSON

The high-speed engine is largely used in England for all purposes, and it may safely be said that more high-speed engines for use on land are manufactured in England than in any other country in the world. The majority of these engines are for use at home, but a great number are sent abroad, English productions in this direction being used in almost every country.

The term "high-speed" is somewhat misleading—although no doubt generally understood—but "quick revolution" is a more correct definition of the type of engine under consideration, as it is high speed of revolution only which makes these engines differ from any other type. All engines running at speeds exceeding 120 revolutions per minute are generally spoken of as high-speed engines, and they are in general use running at speeds up to 700 revolutions per minute for the smaller powers, whereas the speed of the largest engines usually does not exceed 200 to 250 revolutions per minute.

As illustrating general practice of the leading high-speed engine builders in England today the following table is given:

I.H.P.	Revolutions. per Minute.	Piston Speed.
50	600 to 700	600
100	550 to 600	650
200	500	675
500	350 to 375	750
750	325	775
1000	250	800
1500	200	900
2000	160 to 180	1000

The Early High-speed Engine

Although the high-speed engine was first introduced for dynamo driving, it is now in use for almost every purpose, rapid strides having been made during the last few years despite the competition of the steam turbine. Even mill owners have at last recognized the simplicity, reliability and economical working of the inclosed type of engine for driving their mills, but the slow-speed Corliss engine has such a firm hold, and has done so well, that it will be many years before any other type of engine will be largely used. A number of mills, however, are now driven electrically, and as many of them have their own generating plants, another field for development is opened for the high-speed engine.

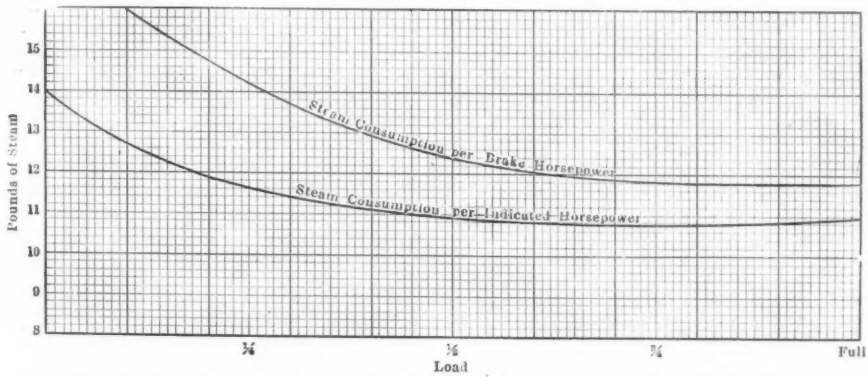


FIG. I. STEAM CONSUMPTION OF A TRIPLE-EXPANSION HIGH-SPEED ENGINE

Piston Speed

The piston speed of the engines is not much in excess of that of slow-speed engines, except in the case of the larger powers. The early high-speed engines were made with short strokes, and consequently with low piston speeds, but during the last few years there has been a tendency to increase the strokes and piston speeds. This has most probably been brought about by the necessity for economy in design necessitated by keen competition. In many instances the strokes have been increased 25 per cent. and the piston speeds accordingly increased 25 per cent. It will be readily seen that from almost the same weight of material 25 per cent. more power is then obtainable.

The early high-speed engines were of the single-acting type, as made by Brotherhood, Willans and others, but this class of engine has been entirely superseded by the double-acting forced-lubrication type of engine. Double-acting engines with ordinary gravity lubrication, when running at high speed of rotation, are most unsatisfactory and will soon knock themselves to pieces, whereas the single-acting engine with its parts always in constant thrust overcame all these difficulties, but it was an expensive and inefficient engine. The introduction of forced lubrication, however, did away with the necessity of single-acting engines and although large numbers of these engines were made after forced oiling was first brought into use, all engine builders of today use forced lubrication and double-acting engines, and none of the single-acting type is manufactured.

Advantages of the High-speed Engine

High-speed engines have many advantages over the slow-speed type. These may be summarized as follows:

A smaller engine is required for a given power, and thus it occupies less space, and reduces the cost of the engine somewhat. Smaller foundations and buildings are required; this again reduces the cost. The high-speed engine is of the simplest type manufactured, is reliable and is subject to a minimum of wear.

It may appear somewhat exaggerated to say that there is considerably less wear in a high-speed engine than in a slow-speed engine, but nevertheless it is a fact, that with high-speed engines of the best makes less adjustments are required than with any slow-speed engine ever built. This is no doubt principally due to the fact that all the wearing parts of high-speed engines are large, and the system of lubrication is most perfect. These points will be more fully considered later, but as a proof of the statement just made with regard to wear, a few particulars are given below of a 500-horsepower three-crank engine after running 7 years, 12 hours per day and 300 days per year:

500-HORSEPOWER THREE-CRANK ENGINE.

Crank pins, greatest wear, inch	0.003
Main bearings, greatest wear, inch	0.003
Eccentric sheaves, greatest wear, inch	0.015
Crosshead pins, greatest wear, inch	0.005

After 5½ years running the wear on parts of a 200-horsepower two-crank compound engine are given below:

200-HORSEPOWER TWO-CRANK ENGINE.

Main bearings, greatest wear, inch	0.0025
H.P. crank pin, greatest wear, inch	0.0050
L.P. crank pin, greatest wear, inch	0.0090
H.P. crosshead pin, greatest wear, inch	0.0035
L.P. crosshead pins, greatest wear, inch	0.0030
Eccentric sheave, greatest wear, inch	0.0080
H.P. piston rod, greatest wear, inch	0.0110
L.P. piston rod, greatest wear, inch	0.0050
H.P. valve rings, greatest wear, inch	0.0055
L.P. valve rings, greatest wear, inch	0.0100

These are not isolated experiences, but are commonly found almost everywhere. It might here be mentioned that all pins where possible are of steel, case-hardened, and this, together with ample lubrication

and the necessary perfection of workmanship put into the engine, accounts for their success.

Again, high-speed self-lubricating engines require much less attendance, and it is common practice to put one man in charge of from four to six high-speed engines in a generating station. This is only rendered possible by the automatic system of lubrication adopted, and is rarely found possible in the case of slow-speed engines.

Economy

There are also many points in their favor as regards economy, and actual tests of modern engines have shown that high-speed engines have at least as high economy and efficiency as any other type of engine manufactured. In Fig. 1 is shown the consumption of steam per indicated and per brake horsepower of a high-speed triple-expansion mill engine working with steam at a pressure of 175 pounds per square inch and exhausting into a condenser having a vacuum of 26 inches, the steam being superheated 100 degrees Fahrenheit. These are the ordinary present-day conditions as regards steam pressure and vacuum for ordinary slow-speed mill engines, so it will at once be seen that the results obtained leave little to be desired. A consumption of 11.8 pounds per brake horsepower, or 10.9 pounds per indicated horsepower being equal to the best Corliss engine results, and owing to the high efficiency resulting from the forced lubrication and throttle governing, the economical performance at light loads is relatively much better than in the case of slow-speed engines.

The type of engine cylinder, viz., piston-valve cylinders, also renders the use of superheat practicable, and great advantages are thereby obtainable. In Fig. 2 is shown the percentage of gain due to superheat ranging from 0 to 200 degrees Fahrenheit on a high-speed triple-expansion engine. From this curve the advantages of superheat are apparent, and 150 to 200 degrees Fahrenheit are quite suitable for high-speed engines. At 200 degrees Fahrenheit the saving in steam consumption is no less than 26 per cent., and although this cannot be counted as total gain, a large percentage of economy is derived from the use of superheat.

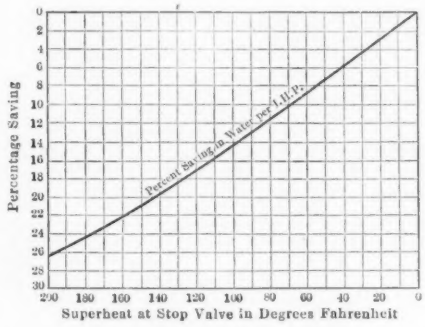


FIG. 2. GAIN FROM SUPERHEAT

Methods of Governing

The method of governing small high-speed engines is most generally by means of a plain centrifugal governor fixed to the crankshaft and acting directly on a throttle valve. In the case of lathe engines several makers are now fitting a governor which at light loads controls the speed of the engine by throttling, and at heavy loads by altering the degree of expansion in the high-pressure cylinders. This has been found the most economical method of governing. In the early days of high-speed engines, many makers used crankshaft governors which acted directly upon the steam-distributing valve and controlled the speed of the engine by altering the cutoff throughout the whole range. This type of governor is largely used in America, and with great success for medium-speed engines, but for high speeds it has been found impracticable and of very little advantage, except perhaps for small engines. The method adopted for governing by expansion in the case of heavy loads only, will be described in detail later.

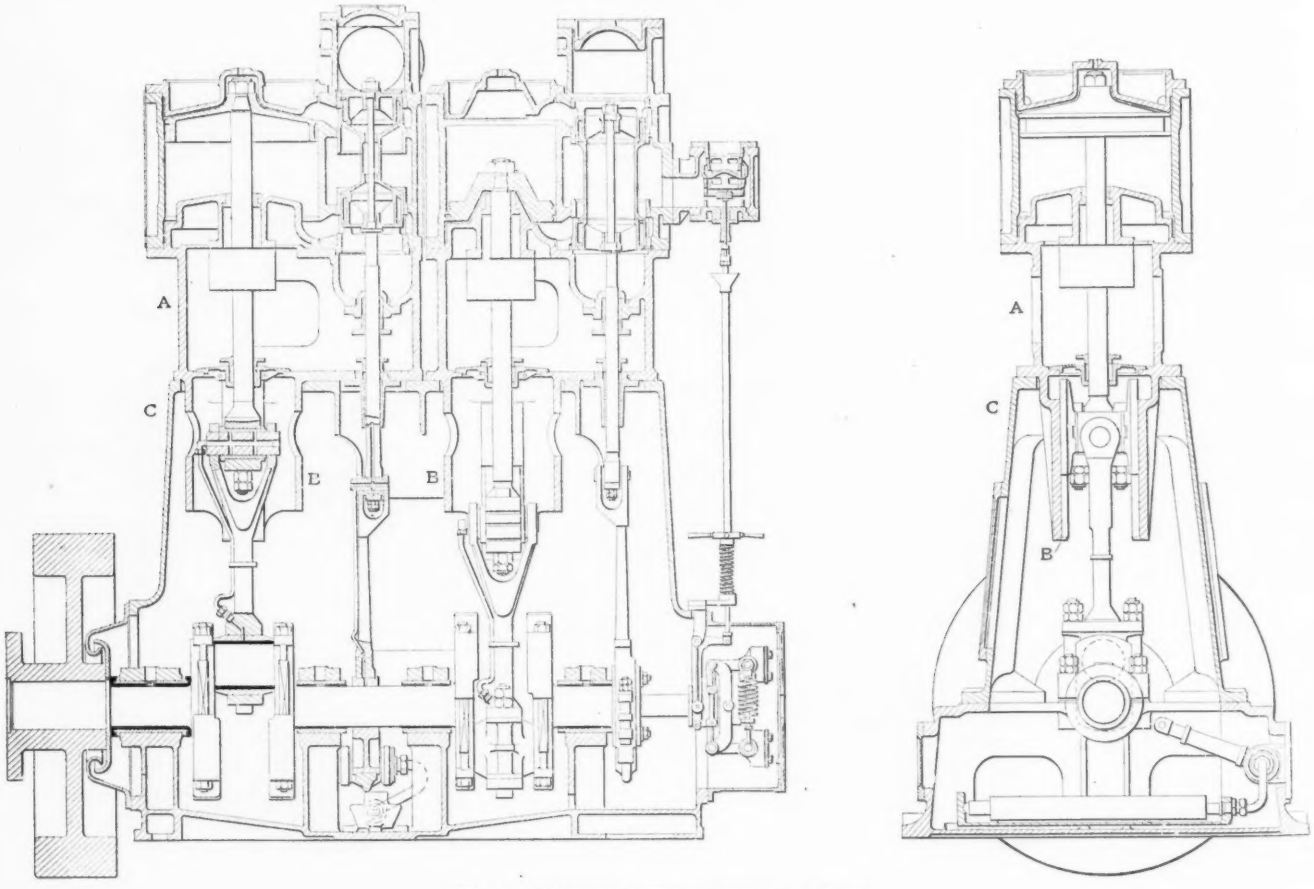


FIG. 3. BROWETT-LINDLEY VERTICAL ENGINE

Standard Type of Details

High-speed engines are built in all the usual varieties, viz., simple, compound and triple-expansion, and the principal British

makers build engines in standard sizes up to 3000 indicated horsepower.

Cylinders. Piston valves for all cylinders are universally used, these being the only satisfactory type to suit all conditions of steam pressure and superheat. The cylinders are simple. In the case of two- and three-crank engines, each cylinder with its line of parts is usually quite independent of the other, that is to say, the cylinders are not stayed together in any way. This leaves each engine entirely free to be centered over its own crank, and also prevents distortion owing to unequal expansion due to the temperature of the steam. Steam jacketing has been tried, and no benefit being derived, it has been abandoned by most makers.

It may be of interest to note that all builders of this type of engine appear to have now adopted one standard design of engine, which consists of four main parts, viz., cylinder, distance piece with which is formed the crosshead guide, frame and bed or base. The arrangement referred to will be clearly seen by referring to Fig. 3, which shows in section the type of two-crank compound engine as manufactured by Browett, Lindley & Co., Ltd., of Manchester, for powers ranging from 300 to 1000 horsepower, and this may be taken as typical of the best standard British design. In this engine the cylinders are supported their full length, but quite independently of each other, by a casting *A* with which is formed the bored guides *B*. In this distance-piece casting are formed large openings, both back and front, to give easy access to the piston rod and valve-spindle glands. Above the guide, that is, at the top of the frame *C*, another set of stuffing boxes are fitted to prevent leakage of water from the cylinders getting down into the engine base, and so mixing with the oil in the crank chamber. The distance between these two glands is usually made a little more than the stroke of the engine, so as to prevent oil being carried up the rod and being drawn through the stuffing box into the low-pressure cylinders, when the engines are worked condensing.

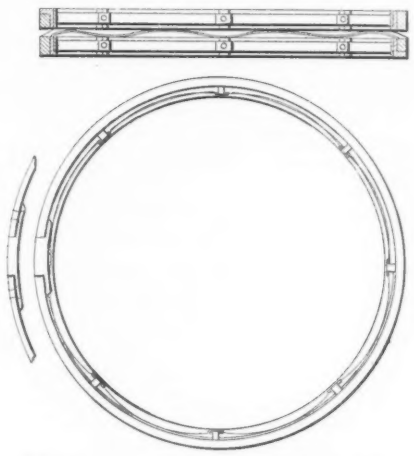


FIG. 4. TYPE OF PISTON RING IN COMMON USE

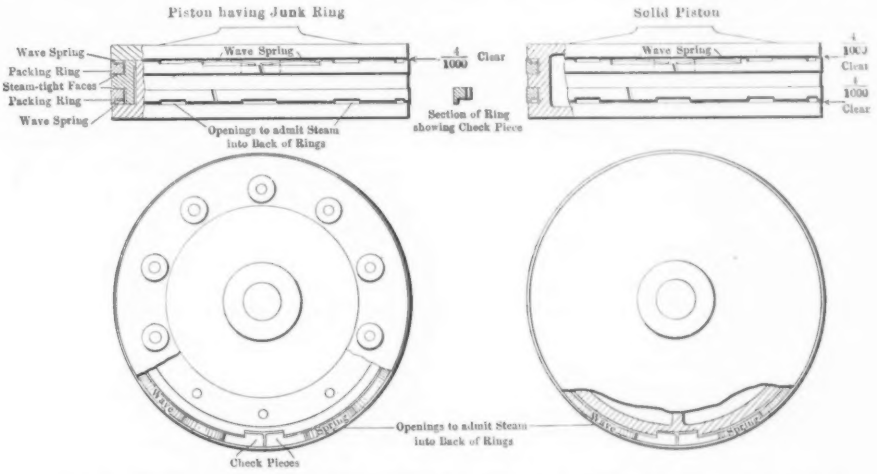


FIG. 6. DOBSON PISTONS SHOWING PATENT CHECK RINGS AND WAVE SPRINGS

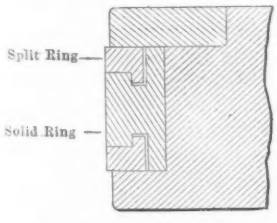


FIG. 5. ADMIRALTY TYPE OF RING

It will be noted that the distance-piece casting also forms the bottom cylinder cover, and as this cover and the crosshead guide are bored out at the same setting and the cover afterward turned on a mandrel fitted into these two machined portions, the guide is self-centering when the cover is fitted into the cylinder.

Pistons. The design of pistons for small engines does not call for any comment, but the low-pressure pistons of compound and triple-expansion engines are usually made of wrought or cast steel. The type of piston ring almost universally used on account of its suitability for quick reversals, is one which consists of two cast-iron rings, Fig. 4, similar to the ordinary Ramsbottom rings, both being placed in one wide groove. Between these two rings is placed a strong wave spring, which keeps them against the piston flanges, and behind each ring another wave spring is fitted, which presses them against the cylinder walls. By suitably proportioning these springs excellent results are obtained. These rings, however, are not suitable for high-pressure cylinders when superheated steam is used, and most makers then adopt a restrained type of ring which is prevented from expanding beyond a predetermined amount by suitable locking-tongue pieces or lugs formed at the joint of the rings. For this purpose the Admiralty type of ring, shown in Fig. 5, has been largely used, and also the type of ring shown in Fig. 6. In this case, as will be clearly seen, check pieces are formed on the rings at the joints, and these engage with suitable recesses formed in the piston or carrier ring, as the case may be. A wave spring is also fitted to each ring to keep it against the piston endwise and, as will be seen, this acts in conjunction with the steam. The outward pressure is obtained by giving the rings a slight initial spring, and by allowing the steam free access behind the rings. The rings are thus steam expanded, but excessive outward pressure is prevented by the check pieces. These rings are practically self adjusting, owing to the very slight wear of the check pieces, and are working satisfactorily with steam superheated up to 700 degrees Fahrenheit.

Piston Valves. As already stated, the type of steam-distributing valve universally used is the piston valve, and what may appear surprising is the fact that almost all engine builders use either solid piston valves or valves fitted with solid floating rings. This type of valve—crude as it may appear—is very satisfactory and with the best of manufacture enables very economical results to be obtained.

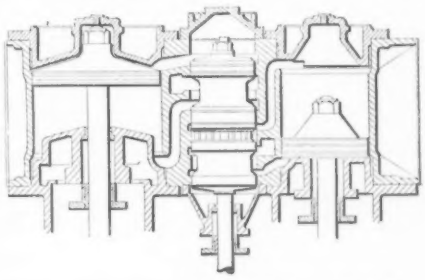


FIG. 7. SIMPLE ARRANGEMENT OF COMPOUND CYLINDERS

Valves with springs or adjustable rings are rarely used, although there is now a tendency to use them owing to the very keen competition existing in the business for the best economy. The piston valve possesses many advantages, among which may be mentioned its simplicity and the accuracy with which it can be actuated

owing to it being perfectly balanced. It is the usual practice to fit liners of hard, close-grained cast iron in the cylinder-valve chests for all except the smallest of engines. For compound engines up to 400 indicated horsepower, one valve placed between the high- and low-pressure cylinders is generally used. The arrangement is shown in Fig. 7, and it is certainly a very simple engine, only one valve and gear being required.

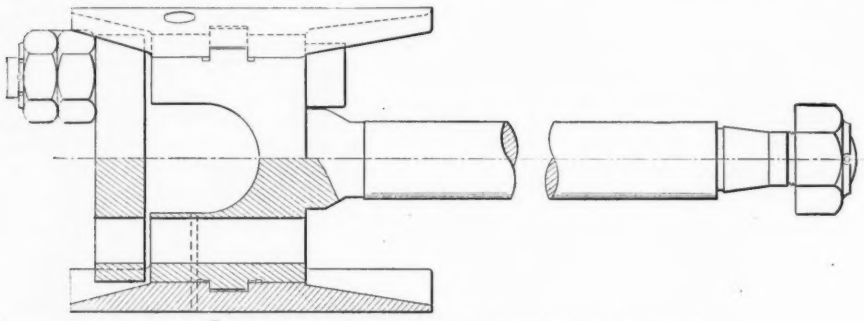


FIG. 8. CROSSHEAD AND PISTON ROD FORGED IN ONE PIECE

Motion Work. The marine type of crosshead and connecting rod is used by all builders, all wedge and cotter adjustments having given place to the simple cap and two bolts. For engines up to about 600 horsepower the crosshead and piston rod are usually forged in one piece, but for larger powers the two-bearing crosshead of the marine type is generally adopted so as to make it easy to withdraw the piston rods and crossheads, which would otherwise be a difficult matter. The design of these details is shown in Figs. 8 and 9.

The piston rods and crossheads are usually made of high-carbon steel, 0.4 to 0.5 per cent., mild steel being used for the connecting rods. The crosshead bushings are made of phosphor bronze, and these working in conjunction with hardened-steel crosshead pins of ample size, are very durable. The crank-pin bushings are lined with white metal in every case. Cast-iron crosshead slippers are always used. Experience has shown that even with the most perfect system of lubrication, large bearing surfaces are necessary; consequently the pressure per square inch is very low. General practice shows the maximum pressure per square inch on crosshead pins to be 900 pounds; on crank pins, 350 pounds, and on crosshead slippers, 40 pounds.

Although the piston speeds of these engines are by no means low, there has been very little tendency to cut down the weight of the parts. In the early engines the parts were made as light as possible, but apparently experience has shown that there is no necessity for this, and that it is far more advisable to make the parts of ample strength and thus to a great extent prevent buckling, should there be a slight rush of water into the engine. With a view to decreasing vibration, connecting rods are made of considerable length compared with the stroke, the average practice being between two and three-fourths to three times the length of the stroke. A few firms, however, make their connecting rods as long as three and one-fourth times the stroke.

Valve Gear. The gear for driving the valves consists simply of an eccentric keyed to the crankshaft, driving the valve spindle through an eccentric rod in the usual way. In small engines the valve rods, together with the crosshead, are made in one piece, and the guide is generally formed by swelling out the valve rod at the bottom end, this working through a long bushing. The design of valve-rod end is similar to that of the piston rod, viz., marine type, a pair of phosphor-bronze bushings being fitted and made adjustable by cap and bolts. Eccentrics are made of cast iron, the latter being in all instances lined with antifriction metal.

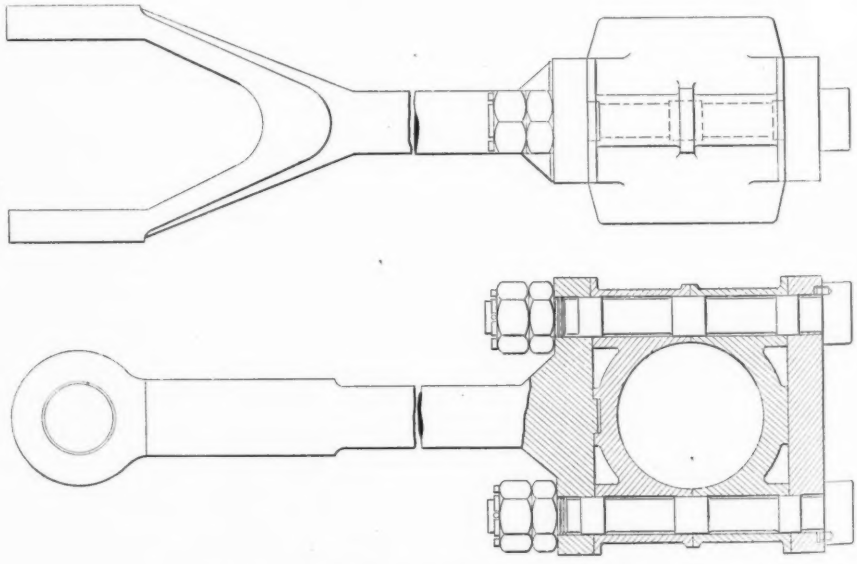


FIG. 9. TWO-BEARING CROSSHEAD OF MARINE TYPE

Main Bearings. The standard practice regarding these appears to be plain bushings of cast iron lined with antifriction metal, the bed with its caps being bored out to receive them. One large firm, however, does not fit loose bushings to the main bearings at all, but simply lines the bed and cap with antifriction metal, afterward boring the lining out in place. Gun-metal bushings for the main bearings are not fitted by any of the large firms except when specified.

It has been found in practice that cast-iron bushings are preferable, and when heating occurs due to foreign substance getting into the bearings, or want of lubrication caused by neglect, cast iron is less liable to close in than gun metal. It is the general practice not to fit liners to any of the bushings, but simply to adjust them, metal to metal, when the main-bearing bolts are tightened hard down. Owing to the ample surface provided in the main bearings of these engines and, as already stated, the excellent system of lubrication, adjustments are very rarely required and certainly not for several years.

Crankshafts. Crankshafts are made from solid forgings of Siemens-Martin acid steel to specification equal to that of Lloyds except for the largest-sized engines, in which case the crankshaft is sometimes built up of three equal parts, couplings being formed solid at the end of each portion. It is more general, however, to make shafts for engines up to 2000 horsepower in one solid piece. The strength of the shafts is somewhat greater than of shafts used in slow-speed practice, but this is principally brought about owing to the necessity for large bearing surfaces. To provide for this, with the ordinary type of shaft, would necessitate a great length of engine, and no advantage would be gained thereby. The pressure per square inch on the main bearings of engines rarely exceeds 200 pounds, this being calculated on the maximum pressure obtainable, as measured from the indicator diagram. This in most instances is the determining factor for the size of the crankshaft.

Flywheels. Owing to the high speed of rotation, the flywheels are necessarily of

small diameter, the maximum speed on the rim usually not exceeding 6000 feet per minute. These wheels are made in plate form and never with arms, this design being most suitable for such small diameters and much stronger than could possibly be made with arms. Owing to the great number of impulses per minute, it has been found that wheels of a fairly good fit and simply keyed on soon work loose, and the practice today adopted by all firms of repute is to make the shaft a forcing fit for the wheel, the latter then being forced on by hydraulic pressure. In the case of large engines, if this system is adopted, the crankshaft and flywheel become a very unwieldly piece of machinery for transit, and owing to this it is usual to form a coupling solid with the crankshaft and carry the flywheel between this coupling and the coupling of the dynamo or extension shaft carrying the wheel in the case of rope driving. This arrangement was first introduced by the late Mr. Willans,

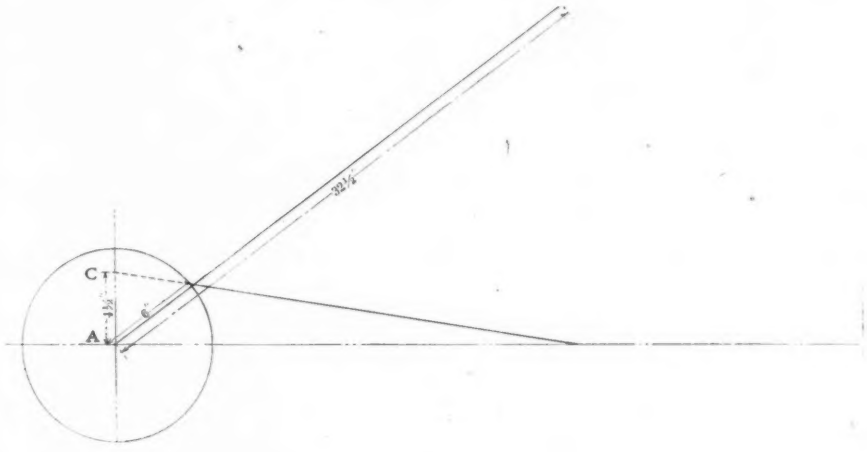


DIAGRAM SHOWING DISTRIBUTION OF THE FORCE OF A BLOW

and it has the advantage of making a very simple flywheel casting. The flywheel practically consists of a heavy rim with an inner plate or rim suitable for attachment to the coupling.

Oil Throwers. In engines of the forced-lubrication type there is a great amount of splash inside the crank case, although none of the working parts are allowed to dip into the oil. It is therefore necessary to provide means for preventing this oil leaking out at the point where the crankshaft comes through the engine base. In the early engines stuffing boxes and packing of every description were used with more or less success, but it has been found that by making a ring of the design shown in Fig. 3 oil leakage is entirely prevented. The arrangement is simple and at the same time perfectly effective. At the governor end of the engine there is no necessity for the crankshaft to come through the casing, and this is generally closed in by an oil-tight door.

Causes of Engine Failure

By R. Cederblom

When an engine gets a dose of water in the cylinder while running at full speed and, as a result, becomes more or less fit for the scrap pile, it is plainly seen that an unusual force was unexpectedly brought into action and it is interesting to look into the case a little closer and see "how it happened." The force in itself is, of course, the kinetic energy of the moving parts of the engine, principally the flywheel, the size of the energy depending on the weight of those moving parts and the velocity at which they were moving at the time of the accident. A hundred-pound weight resting on the floor does not possess energy, but in picking it up and placing it in a higher position a certain amount of work has been expended on it. This amount of work is now stored, so to speak, in the weight in the form of potential energy as long as held stationary at this higher level, but if allowed to drop back to the floor this potential energy is changed into kinetic energy and, in striking the floor, does the same amount of work as was expended in lifting it to a higher level. The same with a steam engine; when steam is admitted to the cylinder on starting up, a certain amount of work is done by the steam in bringing the engine up to speed, part of which is used to overcome friction and should not here be considered; the remaining part goes to give to the moving parts of the engine a certain velocity. As long as the engine is running at uniform speed the work done is simply stored in the moving parts in the form of potential energy, but the instant a sudden load or some obstruction, as water in the cylinder, tends to reduce the velocity of those moving parts, this stored-up or potential energy is instantly brought into play in the form of kinetic energy trying to overcome the resistance offered, the size of the force thus brought into action depending on the time during which the change occurs. In a heavy engine with a ponderous flywheel this force can easily be imagined, but consider a little 12x12-inch affair with light belt-wheels, say 66 inches in diameter, running at 275 revolutions per minute. Suppose the face of the wheel rim is 14 inches and of an average thickness of 1 inch. If we disregard all the other moving parts and consider only the two wheel rims the weight of these would be

$$2 \times 65 \times 3.1416 \times 1 \times 14 \times 0.260 = 1486.606$$

pounds. With 275 revolutions per minute we get a velocity of

$$\frac{65 \times 3.1416 \times 275}{12 \times 60} = 78$$

feet per second, nearly. The available kinetic energy of the two wheel rims is, then, according to the formula

$$\frac{W v^2}{2 g} = \frac{1486.606 \times 78 \times 78}{2 \times 32.16} = 140{,}617.396$$

foot-pounds, where W = the weight of the moving parts, v = the velocity and g = gravity, 32.16. The action of this stored-up energy depends on the nature of the resistance to motion. As water is practically incompressible, if a volume of it should happen to fill the space between the piston and the cylinder head during the compression period of the stroke, when there would be no outlet for it, the action would be identical to the force of a blow. To determine the force of this blow it is necessary to know the time required to bring the moving parts of the engine to rest, if they actually come to rest, which is not at all likely; if resulting in only reducing the velocity the amount of reduction must be known. As such figures are not available, suppose for an instant that the different parts of the engine are of sufficient strength to withstand this blow, i.e., actually to stop the engine without straining the different parts beyond the elastic limit; but that the strain, such as bending of the spokes in the wheel, torsion in the shaft and compression of connecting rod and piston, allows of a movement at the wheel rim of, say, 3 inches or ¼ of a foot from the time the piston brought up against the solid body of water until all parts are at rest. The force developed at the wheel rim would then be the kinetic energy divided by the distance through which it acts in feet, or

$$\frac{140{,}617.396}{\frac{1}{4}} = 562{,}469.584$$

pounds. In the skeleton diagram shown herewith this force is active at the end of a lever 32½ feet in length (the radius of the wheel). As the crank pin is only 6

inches from the fulcrum of this lever, the force at this point is correspondingly greater and, the crank and connecting rod forming a toggle joint, the force or pressure is distributed toward the shaft journals as well as against the cylinder head, which explains the broken journals or split and cracked frame which are often a result from a dose of water in the cylinder. Considering the thrust against the cylinder head alone, if the crank should be in the position shown in the diagram, the distance $C A$, which we get by prolonging the line representing the connecting rod until it intersects the vertical center line, would be about 4½ inches. The thrust on the head would then be

$$\frac{562{,}469.584 \times 32\frac{1}{2}}{4\frac{1}{2}} = 4{,}062{,}280.329$$

pounds, or

$$\frac{4{,}062{,}280.329}{12 \times 12 \times 0.7854} = 35{,}918.233$$

pounds per square inch, all on the assumption that the engine was strong enough to withstand the shock. No engine, however, is built to do so and some part is smashed long before the full kinetic energy has been developed.

Cost of Producing Electricity

E. A. Ashcroft, in a paper recently presented to the Faraday Society, estimates the cost at which electricity can be produced in a 5000-kilowatt plant as £8 6s. 6d. per kilowatt-year for steam, £6 18s. for gas engines and £7 4s. for oil engines. The items are fuel, labor, upkeep (comprising maintenance and depreciation) and capital charges. He divides water power into two classes: first-class powers yielding an even supply all the year round without high cost of regulation or of development, with which sort of a plant he estimates that a kilowatt-year can be produced for £2, made up of fuel, 6s.; upkeep, 8s.; capital, 13s.; royalties on rights, 13s. The cost for water powers of the second class he estimates at £5 6s. per kilowatt-year, made up of fuel, 8s.; upkeep, 13s.; capital, £4 2s.; royalties on rights, 3s.

Mr. Ashcroft was quite aware that water powers of his first class are not often met with. He mentions a development near Vacheim on the Sogne Fjord capable of yielding 7500 kilowatts, or 1000 horsepower, which can be developed for less than £5 per horsepower, including payments for dam rights. At Meraker, near Trondhjem, 3000 horsepower had been sold at £1 5s. 6d. per electrical horsepower on a seven-year contract, and at Notodden (the Birkeland Nitrate Works) the price was £1 8s. per horsepower for 3000 electric horsepower. Water power is being more closely studied than it used to be; several governments, Swiss, Bavarian, Würtemberg and others, have now taken up the problem quite seriously.

A New Departure in Flexible Staybolts*

The increasing size and pressure of boilers makes this subject of vital importance to those who are responsible for the management of that type of boiler in which the firebox is stayed by a large number of bolts.

In recent years some form of flexible staybolt, that is, one having a movable joint, has been very extensively used in the breaking zone of locomotive boilers, but their high cost and the difficulty of applying them, their rigidity from rust and scale and the fact that their use throws an additional service on the adjacent bolts because of lost motion has militated against their more general use.

It is well known that staybolts fail not because of the tensional loads upon them, but from flexural stresses induced by the vibration resulting from the greater expansion of the firebox sheets than of the outside sheets; but notwithstanding the general acceptance of this theory, engineers have designed staybolts solely with respect to the tensional loads. It is quite general practice to recess the bolts below the base of the threads and this has effected a slight reduction in the fiber stress, but practically no effort has been made to design a bolt to meet the flexural stresses or even to calculate their magnitude. The stress increases in direct proportion to the diameter and decreases as the square of the distance between the sheets.

It is obvious that the remedy does not lie in the use of a slow-breaking material, but in the employment of a material of sufficiently high elastic limit to meet the conditions of service. It is also possible to reduce the diameter of the bolts greatly by the use of such a material, thus proportionately reducing the fiber stress in flexure.

Staybolt material, however, must possess sufficient ductility to enable the ends to be readily hammered over to make a steam-tight joint and to afford additional security against pulling through the sheets. To meet these conditions the bolt shown herewith has been designed, of the same grade of steel as that used in the manufacture of springs. It is oil-tempered and will safely stand a fiber stress of 100,000 pounds per square inch. Its high elastic limit makes it possible to reduce the diameter to ⅜ or 7/16 of an inch, or even less. The ends are of soft steel and it is thus possible to apply and head up the bolts in the usual manner.

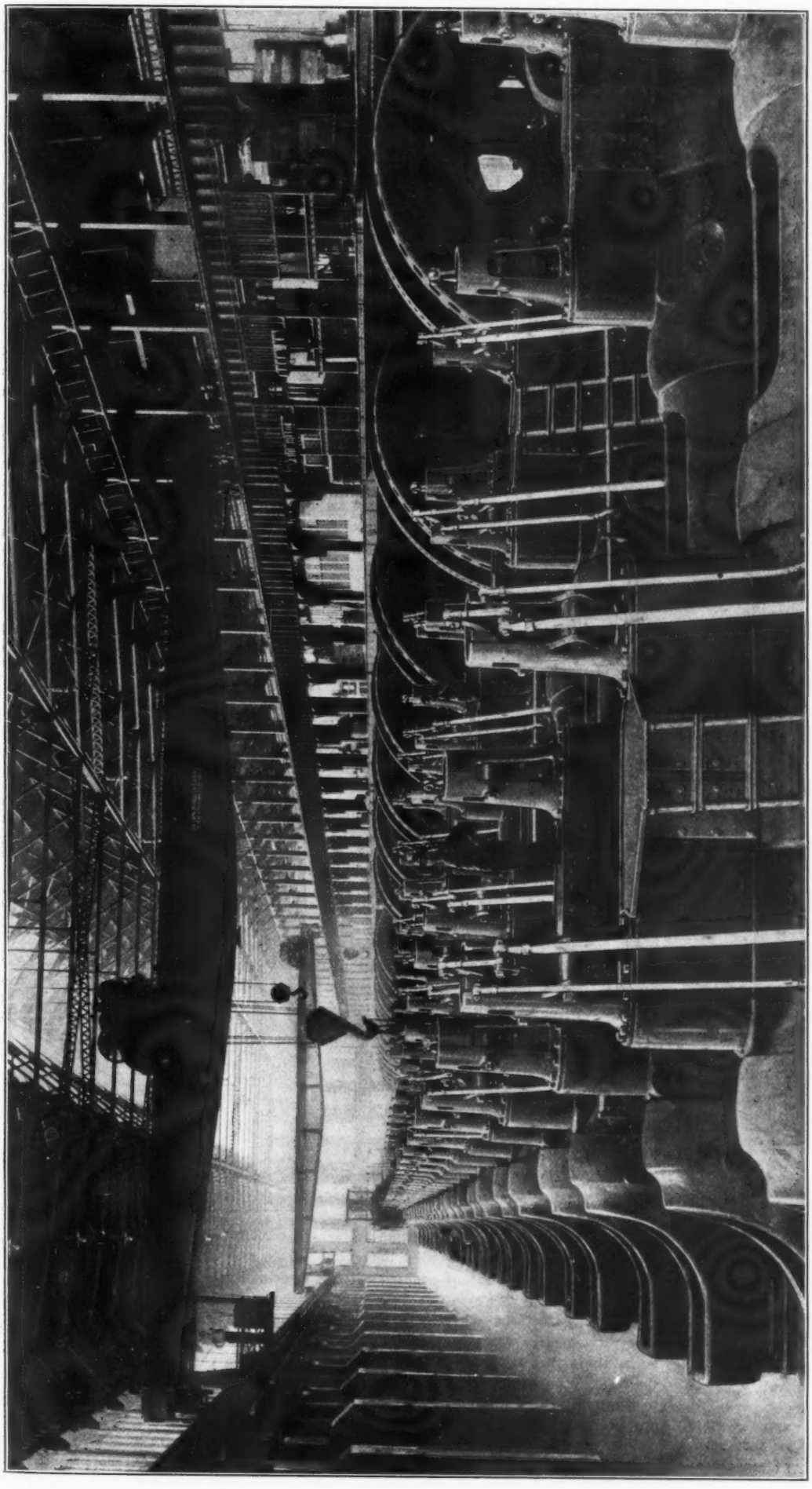
Tests were made of such a bolt in comparison with ordinary iron bolts by clamping one end of the bolt in a machine and revolving the other end through a radius of 3/16 of an inch, the specimen being 6 inches long from the end of the right head to the center of the rotating head. A tensional load of 4000 pounds was also applied to the bolt. A 1-inch iron bolt having an actual breaking strength of 32,500 pounds and weighing 20 ounces broke with 6000 such vibrations. An iron bolt ⅞ of an inch in diameter, having an actual breaking strength of 24,500 pounds and weighing 15 ounces, broke with 5200 such vibrations, while a spring-steel stem bolt, 1 inch in diameter at the end and 7/16 inch in the stem and with an actual breaking strength of 32,000 pounds and weighing 10 ounces, withstood 500,000 such vibrations without breaking. On some such bolts the test was continued to a million vibrations without failure. The paper contains a calculation to show that with staybolts spaced 4 inches apart and with a temperature of the inside sheet of 400 and of the outside sheet of 100 degrees, the expansion between two bolts will be 0.0079 of an inch and each bolt will deflect 0.00395 of an inch. This amount of deflection will stretch the usual type of bolt beyond the elastic limit. In practice, however, one bolt may hold rigidly, throwing the entire deflection on the adjacent bolts, or neither bolt may deflect and the sheet will then buckle. The author figures that under the conditions assumed and supposing the bolts to be rigid, the sheet would buckle ⅛ of an inch, which must ultimately lead to a crack in the furnace sheet. If, however, the bolt deflects, allowing the sheet to normally expand, the latter will be relieved of the extraneous load.

FLEXIBLE SPRING-STEEL STAYBOLT

A bolt of sufficient flexibility to deflect under the forces following expansion and of material which will not be stretched beyond the elastic limit in resisting these forces will greatly assist in reducing the cost of boiler maintenance by eliminating broken staybolts and reducing the stresses in the furnace plates. If, in addition, the bolt has a smaller diameter, the life of the furnace plate should be farther increased, as such bolts will interpose less obstruction to the circulation of the water in the water legs.

*Abstract of paper by H. V. Wille presented before the American Society of Mechanical Engineers.

One advantage in using large boiler units is the reduction in heat units lost by radiation per pound of coal burned and pound of water evaporated.



VIEW IN THE 85,000-HORSEPOWER GAS-ENGINE POWER HOUSE AT GARY, IND. THIS STATION CONTAINS SEVENTEEN TWIN TANDEM GAS ENGINES OF 5000 HORSEPOWER EACH, DRIVING FIFTEEN 2500-KILOWATT THREE-PHASE ELECTRIC GENERATORS, WHICH DELIVER CURRENT AT 6600 VOLTS AND 25 CYCLES, AND TWO DIRECT-CURRENT 250-VOLT GENERATORS OF THE SAME CAPACITY. EACH ENGINE OCCUPIES A FLOOR SPACE 70 FEET LONG BY 44 FEET WIDE AND WEIGHS ABOUT 1,700,000 POUNDS. THE CYLINDERS ARE 44 INCHES DIAMETER OF BORE AND THE STROKE IS 54 INCHES. THE PISTON SPEED IS 750 FEET PER MINUTE AND THE FLYWHEEL-RIM VELOCITY IS 6020 FEET PER MINUTE. EACH FLYWHEEL WEIGHS ABOUT 200,000 POUNDS. THE STATION IS 966 FEET LONG AND 105 FEET WIDE, WITH FORTY-TWO 23-FOOT BAYS

The Installation of Direct-Current Motors

Plain Directions for Setting Up and Operating Motors, with Some General Rules, Observance of Which Will Insure Excellent Results

BY R. H. FENKHAUSEN

When installing motors of any type, one of the first requirements is a knowledge of the proper size of wire to use. Many excellent wiring tables have been compiled for this purpose, but in case none is available the following formula will give the correct size:

Let $c.m.$ = Circular mils in required size,
D = Distance in feet one way,
I = Current in amperes at full load,

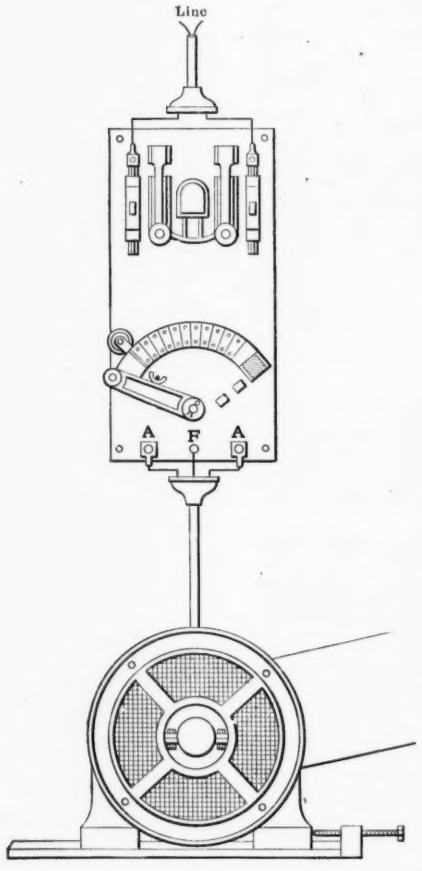


FIG. 1

V = Volts lost in line,
21.5 = Constant = resistance of a two-wire circuit 1 foot long, of wire 1 mil in diameter.

$$c.m. = \frac{I \times D \times 21.5}{V}$$

EXAMPLE: Twenty-five amperes at 110 volts must be transmitted 300 feet with 5 per cent. drop; 5 per cent. of 110 volts is 5.5 volts. Substituting the known values for the corresponding letters of the formula:

$$\frac{25 \times 300 \times 21.5}{5.5} = 29{,}318.$$

This is the required cross-section in circular mils, and it will be found by reference to Table 1 to fall between Nos. 5 and 6 of the standard sizes; either of these sizes will be close enough for practical use, or one wire may be run of each size for closer results.

The full-load current taken by various motors may be obtained from Table 2, calculated by the formula

$$I = \frac{H.P. \times 746}{E \times e},$$

where
I = Current in amperes,
$H.P.$ = Rated horsepower of motor,
746 = Watts in 1 horsepower,
E = Voltage of circuit,
e = Efficiency, varying from 50 per cent. in very small motors to 95 per cent. in large motors, 87 per cent. being an average efficiency for moderate-sized machines.

The result obtained by use of this formula should be increased by 25 per cent. at least, to allow for overloads on the motor.

The wiring may either be run open or inclosed in iron conduit, but around industrial plants open work will usually give better satisfaction when large-sized wires are to be run, owing to the greater facility in installing the wires and accessibility when repairs, alterations or extensions are to be made to the distribution system.

Separate Supply Circuits Desirable

Separate circuits should be run for motors; if they are supplied from lighting circuits the rush of current at starting will cause disagreeable fluctuations at the lamps. This applies particularly to elevator and other motors requiring frequent starting and having widely varying loads. In cases where the 110-220-volt three-wire system is used to supply both lamps and motors, no motors larger than ¼ horsepower should be connected to the neutral and one main wire, or serious unbalancing of the system will result.

The supply line to each motor should terminate at a starting panel containing the fuses or circuit-breaker, main switch and starting or speed-regulating rheostat. The fuses should be of the inclosed type and their proper capacity may be ascertained in the same manner as that of the line wires, except in such cases as where a starter with an overload release is used or where a circuit-breaker is used in addition to the fuses. In these cases the fuses are not intended to blow unless the

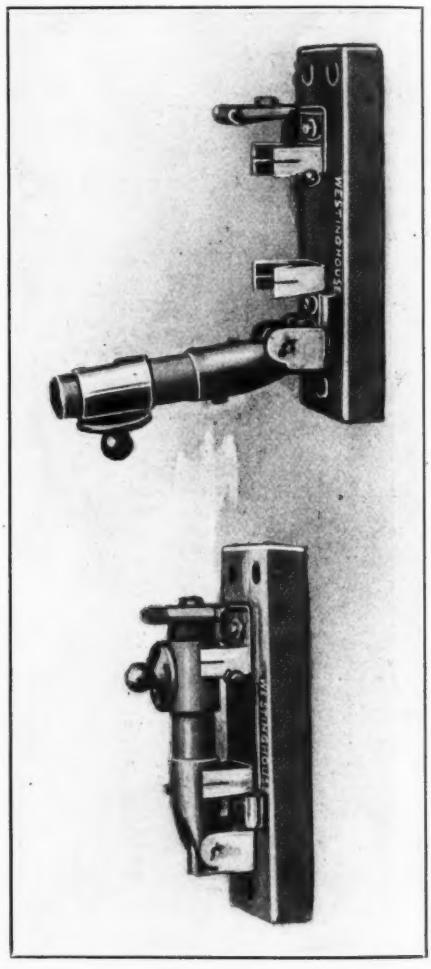


FIG. 2

overload-release or circuit-breaker should become inoperative, and therefore they should be of greater capacity than when they are used as the only safety devices. Table 3 gives the fuse ratings recommended by one of the largest controller manufacturers in the United States.

Switches and Connections

All switches for currents in excess of

25 amperes should be of the quick-break type, as the arc drawn by opening a direct-current circuit is much more destructive than one formed with alternating current. Self-contained motor panels carrying all necessary apparatus are on the market and their use is advisable, where the slight extra cost will not be a detriment. Fig. 1 shows such an installation. Fig. 2 shows a cheap but reliable single-pole carbon circuit-breaker recently placed on the market, and intended as a substitute for fuses. It is made in capacities up to 75 amperes at 250 volts, on direct current, and when installed one in each lead of the circuit not only renders a switch and fuses unnecessary, but makes the motor circuit nonclosable on overload, as one breaker will trip as soon as the other is closed if a short-circuit or heavy overload is still on the line.

Fig. 3 shows complete connections for a motor with regulating and reversing controllers. When a large machine is driven separately by its own motor an ammeter should be connected in its circuit and mounted on the motor panel in order that the operator may avoid overloading the motor, by observing the ammeter indications. If this ammeter be of the recording type it will give a valuable record of the time the machine is idle, the load fluctuations and the manner in which the controller is handled; this will usually make the operator more careful, with a consequent decrease in power and repair bills.

Motor Frames and Location

The "heads" or journal brackets of nearly all motors are bolted on with four bolts or some multiple thereof, which allows the same motor to be mounted on the floor, wall, or ceiling simply by rotating the heads through 90 degrees or 180 degrees, as required to bring the oil wells into position. Fig. 4 shows a standard motor frame, fitted with interchangeable heads for special uses.

Motors mounted on ceilings or other inaccessible places are more liable to be neglected than if placed where they can be easily inspected; therefore, motors should, if possible, be located in a clean, dry and well-lighted place where any accumulation of dirt or grease will be readily noticed by the attendant. When a motor must be set close to a wall, the pulley side should always be next to the wall; this will not only make the commutator and brushes more accessible but allow the belt to be located where it is out of the way. When locating a motor, especially a larger one, do not forget that it may be necessary to dismantle it for repairs some day, and leave room to remove the armature without shifting half the machinery in the shop; also bear in mind that the load that a motor can safely carry is governed by the allowable heating and that, therefore, a motor inclosed in a box without ventilation will only carry about three-fourths of the load that could be carried if the motor were given proper ventilation. The ratings of open, semi-inclosed and wholly-inclosed motors illustrate this very effectively. Because of the poorer ventilation of the two latter types they are given lower ratings by the manufacturers than open motors of the same size and windings.

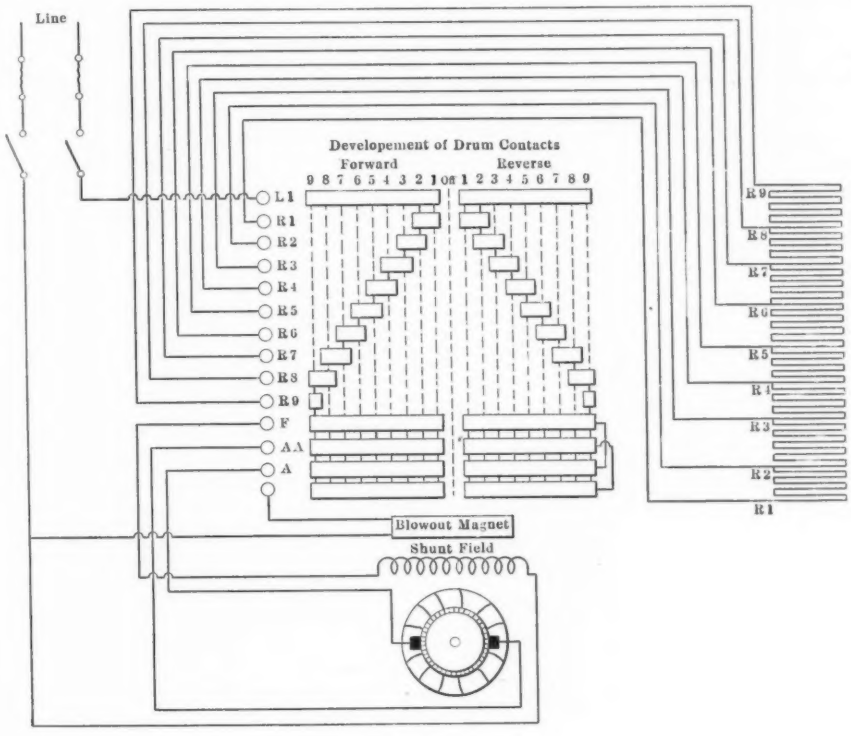


FIG. 3

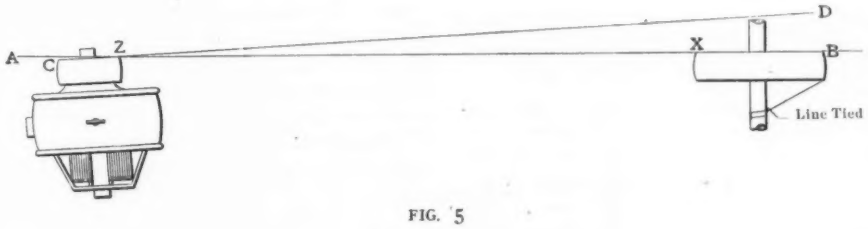


FIG. 5

Setting Motors on the Foundations

The frames of 110-volt to 250-volt motors should be insulated from the ground, but on circuits of 500 volts or over the motor frame should be well grounded to prevent injury to the attendant in the event of a ground in the motor

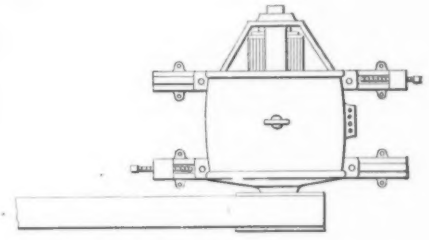


FIG. 4

winding. Before attempting to bolt a motor to its foundation one should make sure that the foundation is perfectly true and level, then locate the slide rails as close as possible, setting them with the adjusting screws at opposite ends, as illustrated in Fig. 4, but do not bolt them down. Place the motor in position on the rails and line it up with the driven pulley. A silk line should be procured and by aid of a helper stretched across the face of the driven pulley, as indicated by the line *A—B*, Fig. 5, one man holding the line taut at the point *A* and the other signaling to him when the line barely touches at the point *X*. The line is now secured at *A* and the motor moved until both edges of its pulley just touch the line. Some men go this far and call the motor lined up, but if satisfactory results are desired a line should be placed across the edges of the motor pulley and by aid of a helper stretched away from the driven pulley. The line *C—D* shows the result (exaggerated), which must be corrected by shifting the motor around until the lines *A—B* and *C—D* coincide. If the two pulleys are of different width, an allowance of one-half the difference in the faces must be made when lining up.

After the motor is lined up the rails should be bolted down and the motor moved toward the driven pulley as far as possible before taking the belt measurement, which will allow maximum adjustment before it becomes necessary to shorten the belt. Whenever possible the driving stretch of the belt should be the lower one. The pulleys should be as far apart as conditions will allow; the belt may then be left slack and a large arc of contact with the pulleys obtained, decreasing the wear on the belt, bearings and shafting and materially reducing the friction loss of the drive and the motor current in consequence. The belt should preferably be endless, but under no consideration should a belt fastening be used that is thicker than the belt itself; if it is, a disagreeable jar will be felt each time the joint strikes the motor pulley. In putting on an endless leather belt care must be used not to run the belt against the laps; otherwise the thin edges of the laps will gradually loosen until the pulley catches them and rips the belt apart. Before starting a motor be sure that the bearings are filled with a good quality of engine oil, and see that all oil rings rest on the shaft and turn with it. If the brushes are not fitted to the commutator a piece of sandpaper should be held around the commutator with the rough side up and the armature rocked back and forth until the brushes are properly fitted, after which they should be set on the neutral point. The "no-load" neutral point is usually located at the factory by chisel marks on the rocker arm and frame. For reversing the motors the brushes should be set exactly on this point, but for nonreversing motors they should be moved back slightly in the direction opposite to the rotation of the commutator, until sparkless commutation is obtained with full load. When reversing motors are heavily loaded running in one direction and only lightly loaded when reversed, "back lead" should be given the brushes for the direction of rotation in which the motor is heavily loaded.

Starting Up and Shutting Down

In starting up, first close the main switch and then slowly cut out the resistance until full speed is reached. If the motor runs in the wrong direction it must be shut down and the brush leads reversed. In series- or shunt-wound motors, either the brush or the field connections may be reversed to change the direction of rotation, but for compound-wound or interpole motors, the brush connections alone may be changed; otherwise there is danger of reversing the series or compensating windings. For this reason it is well to adopt the rule of changing the brush connections, regardless of the kind of winding. If the series winding of a compound-wound motor is reversed, the application of a heavy load to the motor is liable to cause the series-field winding to overpower the shunt winding and possibly cause the reversal of the motor, with disastrous results. A sure test for the series-field connections is to put a light load on the motor and then short-circuit the series-field winding. If the speed of the motor increases the connections are correct, but if the motor slows down the series winding is reversed and should be changed immediately.

When shutting down a motor do not pull the rheostat arm away from the retaining magnet, but open the main switch and the rheostat will release as soon as the motor slows down. Many operators are puzzled by the fact that the retaining magnet does not release the rheostat arm until the motor speed has dropped about 50 per cent. This is due to the fact that the retaining magnet is energized by the counter-electromotive force of the armature, which also keeps the shunt-field winding excited, until its speed is no longer sufficient to hold up the voltage.

The shunt-field circuit of a motor must never be suddenly broken, even though the armature be stopped, as the sudden opening of a highly inductive circuit, such as that of a shunt-field winding, causes an induced voltage greatly above the normal voltage at the terminals of the winding, if the circuit is broken very quickly, and this may puncture the insulation of the motor windings. If the circuit must be broken it should be done by gradually drawing an arc until it breaks. Most motor starters are so connected that the field winding discharges the induced voltage through the armature and resistance when the rheostat arm flies to the "off" position.

TABLE 1. UNDERWRITERS' WIRE TABLE.

Maximum Current.

B. & S. Size.	Rubber-Covered Wire.	Weather-proof Wire.	Circular Mils.
14	12	16	4,107
12	17	23	6,530
10	24	32	10,380
8	33	46	16,510
6	46	65	26,250
5	54	77	33,100
4	65	92	41,740
3	76	110	52,630
2	90	131	66,370
1	107	156	83,690
0	127	185	105,500
00	150	220	133,100
000	177	262	167,800
0000	210	312	211,600

TABLE 2. RATING OF DIRECT-CURRENT MOTORS.

Full Load Current.

H.P.	115 Volts.	230 Volts.	500 Volts.
⅛	1.9	0.95	0.42
¼	2.7	1.35	0.62
½	5.0	2.50	1.15
¾	7.5	3.75	1.70
1	9.2	4.60	2.10
2	17.5	8.75	4.00
3	24.6	12.30	5.60
4	32.0	16.00	7.50
5	40.0	20.00	9.20
7½	57.0	28.50	13.00
10	76.0	38.00	17.50
15	110.0	55.00	25.00
20	144.0	72.00	34.00
25	176.0	88.00	40.00
30	210.0	105.00	49.00
35	250.0	125.00	57.00
40	280.0	140.00	65.00
45	320.0	160.00	75.00
50	350.0	175.00	80.00
60	430.0	215.00	100.00
75	520.0	260.00	120.00
100	700.0	350.00	160.00
125	880.0	440.00	210.00
150	1056.0	530.00	245.00
175	1230.0	615.00	280.00
200	1400.0	700.00	325.00

TABLE 3. FUSES FOR MOTORS.

With Overload Starting Boxes.

H.P.	115 Volts.	230 Volts.	500 Volts.
¼	4	2	1
½	8	4	2
1	15	8	4
2	30	15	7
3	40	20	10
4	50	25	12
5	60	30	15
7½	90	45	20
10	115	60	25
15	175	90	40
20	225	115	50
25	300	150	60
30	350	175	75
35	400	200	90
40	450	225	100
50	600	300	125
60	700	350	150
75	800	400	200

Curing Warm Bearings

In case the bearing of a motor becomes too warm do not stop the machine, because the babbitt will contract and grip the shaft and necessitate rebabbitting; keep the machine running slowly, with the load off, and keep pouring cool oil on the bearing until it cools down to a safe working temperature. The motor may then be stopped and the bearings should be removed and any slight roughness on the shaft or bearings removed with a file or scraper; the bearings should then be calipered and if not too loose may be replaced. If, however, the bearings are badly cut, there is no remedy save rebabbitting.

When the fuse or circuit-breaker in a motor circuit opens the circuit, the main switch should be opened the first thing. Then the circuit-breaker (if there is one) should be closed and again tripped by hand to make sure that burning of the contacts has not rendered it inoperative. The breaker should then be closed (or the fuse replaced) and the motor started as usual. If the fuse or the breaker again "blows," trouble must be looked for in the motor, as will be explained in a subsequent article.

In plants where many motors are in use, the various departments should be divided into routes and these routes should be so laid out that one of the motor inspectors will visit each motor at least twice each week. The inspector should carry an oil can and keep all oil wells filled to the proper hight, being careful to remove the side plugs when filling, in order to avoid getting the wells too full. He should also inspect the bearings and by testing the air gap satisfy himself that they are not dangerously worn. The commutator should then be inspected and

if necessary smoothed down with sandpaper (never emery cloth), after which the brush tension should be tested by raising each brush from the commutator, being careful that all brushes of the same group are in contact with the commutator before raising any brush of that group. If the commutator needs lubrication it should be lightly touched with a clean, slightly oily rag (never use waste) and the surplus oil immediately removed with a dry cloth.

Lubricants for Cylinders

By John M. Sewell

A perfectly smooth surface exists only in theory. With the most modern appliances it is possible at the best to produce only a comparatively smooth surface and when two surfaces of this kind come together in sliding contact, their roughness is evidenced by the frictional resistance to the motion and the wear of the surfaces in contact. The interior surfaces of the cylinders fitted with the reciprocating pistons, together with pistons themselves, form excellent examples of surfaces in sliding contact. Lubricants are used to reduce both the frictional resistance and wear. This is accomplished by interposing a thin layer or film of the lubricant between the two moving surfaces, filling up the minute depressions and preventing the very small projections of one surface from engaging with and dislodging similar projections on the other surface.

The question of cylinder lubrication is an attractive one, and it is one that is extensive in its scope. However, for the purpose of discussion, all cylinders requiring lubrication may be grouped under four heads or classes: First, the cylinders of the steam engine; second, the cylinders of explosive motors or gas engines; third, the cylinders of air compressors and ammonia compressors; fourth, the cylinders of pumps and hydraulic machinery. These classes may be farther distinguished by the position of the cylinder, whether vertical or horizontal.

It has been argued that oil, or its equivalent, need not necessarily be used on sliding surfaces, but that water will serve the purpose. This cannot be denied, for when water is used, it forms a film between the moving surfaces and reduces the friction. But water cannot by any means replace oil or grease as a lubricant.

Water lubricant has been used in vertical types of engine, but without much success, and in every case where oilless lubrication is practical, it would be advisable to inquire into the effect on the coal pile before coming to any definite conclusion regarding the economy of that kind of lubrication for use in engine cylinders. It is clearly impossible to avoid the use of some sort of lubrication in a majority of cases, no matter how nicely water may work under certain conditions.

The Conditions to be Met

The question is, then, to obtain the lubricant for the existing conditions and no one can tell these conditions better than the man in charge of the machinery, for the conditions are not always the same in all cases. Some conditions to be met with are: First, the iron of which the cylinders are made is different and needs better lubricant; second, the location of the valves may be different, which would make necessary a better kind of lubricant; third, high temperature, due to heat or steam, the heat caused by compression, or the heat generated by the combustion of the charge in the explosive chamber; fourth, water due to the condensation of steam on account of the cooling effect of the cylinder walls; fifth, water retained by the steam and carried over from the boilers into the cylinders, which may often contain many troublesome impurities; sixth, friction due to the pressure of the pistons and valves against the walls of the cylinders and steam chest.

As a consequence of these conditions, a cylinder oil or other lubricant to be valuable must possess the following characteristics: First, it must have a high flashing point or point of decomposition under the effect of the heat; second, it must possess sufficient body to keep the surface free from contact under pressure; third, it must be as fluid as consistent with pressure conditions; fourth, it must be capable of resisting the action of the atmosphere; fifth, it must be free from corrosive action upon the metals of which the surfaces are composed. It can therefore be seen at a glance that the conditions cannot be met with any single lubricant, but must be compounded.

The selection of a cylinder lubricant therefore necessitates a study and long experience of the conditions of the temperature, pressure, speed and moisture, and a great deal of watchfulness. In the first place if you have a poor oil the damage is done before you are aware of it.

It is not an easy matter to determine what lubricant is best adapted for the particular cylinder, but when this has once been determined, this grade should be used continually, as long as it gives satisfaction. Much of the trouble due to the cutting and scarring of the valve seats and cylinders is due to the use of poor cylinder lubricants.

It has come to be a generally accepted statement, upheld by years of experience, that the best lubricant for cylinders is a mineral-compounded oil of good body and high flashing point, for a purely mineral oil contains a great number of good qualities which go to make a valuable cylinder compound.

The Different Classes of Oil

Oil is divided according to the sources from which it is obtained into three classes: Mineral oil, such as produced from oil wells and bituminous shale by the process of distillation; vegetable oil; animal oil. Vegetable and animal oils possess certain properties which make them totally unfit for a cylinder compound. They decompose easily and if the atmosphere is warm and moist, the decomposition becomes greatly hastened. These conditions of heat and moisture exist in every steam cylinder, and to a certain extent in the cylinder of explosive engines. Hence the use of either of these oils must be regarded as contrary to good practice.

Let us note just what takes place when either of these two oils is used in the makeup of a cylinder compound. Tallow is a compound of stearic acid, or a stearine composed of carbon, hydrogen and oxygen. When it meets with steam or hot water the action of the heat decomposes the tallow to a certain extent and a portion of the disassociated atoms, combined with a portion of the hydrogen and oxygen of the water form new compounds, so that where originally there were stearine and water, there are now stearine acid and glycerin. This stearine acid being in a free state is now left to attack the metal of the cylinder, which it does with great vigor; pitting the surface of the cylinder, pistons and valves until they are ruined or, as in many cases, to such an extent that the cylinder is blown to pieces. The same action would take place if palm, vegetable or lard oils were used. For in palm oil we get palmic acid and in the lard or vegetable oils we get oleric acid, set free. Both of these acids would attack the cylinder just as readily. These disadvantages precluding the use of fatty oils leaves the field open chiefly to mineral oils.

As previously stated, mineral oils for lubrication are obtained from crude oil by the process of distillation. The heavy oils used for cylinder lubricant are those left in the still; when the distillation is almost complete, they represent the least volatile components of petroleum. When a quantity of crude oil is placed in the still and subjected to the action of the heat, the first product volatilized and driven off is crude benzine. This occurs at from 175 to 300 degrees Fahrenheit. If the temperature is then raised, a second class of distillate will be formed, including illuminating oils. These are driven off by raising the temperature from 300 to 571 degrees. There then remains in the still a thick, heavy residuum, black in color, which possesses tar, paraffin oil and lubricating oil. It is possible to use this residuum for lubricating purposes after filtering, but the lubricant thus obtained is only fit for wagon wheels and similar places where a gummy lubricant can be used with efficiency.

Specific Gravity and Viscosity

At first the ordinary lubricant oils were obtained from the residuum by further heating and distillation, but this destroyed many of their valuable lubricating properties. At present, this residuum is treated in a vacuum, or in superheated steam, which prevents decomposition of the distillate and preserves its lubricating properties. The first products of this final distillation are the higher machine oils and the last products are for the heavy machine and cylinder oils. At one time the specific gravity of an oil was made the criterion by which it was judged and selected. That is, the oil possessing the highest specific gravity was thought to be the best suited for cylinder lubrication, but this theory was soon exploded when it was found that some of the machine oils possess more specific gravity than the more viscous oils.

Then viscosity was made the standard of comparison and this to a great extent is the characteristic which influences the selection of oils at the present day. But even this properly cannot be relied upon, for the very reason that the viscosity may not be due to the friction and cohesion of the oil molecules alone, but to the presence of paraffin, in which case its value as a lubricant may be even less than that of an oil of less viscosity but possessing a smaller per cent. of paraffin. Farther than this, the viscosity of an oil changes with its temperature, the higher the temperature the less viscous it becomes. What is desired, then, is an oil the viscosity of which at the actual working temperature will still be sufficiently great to prevent its being squeezed out from between the rubbing surfaces under the effect of the pressure.

Another impurity in oil which lowers its efficiency as a lubricant is sulphur. This may be present owing to the improper methods of refining. To determine whether sulphur is present, heat a very small quantity of oil, say for fifteen minutes, at a temperature of 300 degrees Fahrenheit and then allow it to cool. When cool, compare the color of the treated sample with that of the untreated oil and if the treated sample shows perceptible darkening, it may be safely assumed that sulphur is in the oil.

Requisite Qualities for Cylinder Lubrication

This brings us, then, to a consideration of the qualities of the oils required for lubricating the four kinds of cylinder referred to: In selecting an oil for steam cylinders the viscosity should be proportional to the weight and the speed of the piston. The flashing point must be governed by the steam pressure carried. If this is high, then the oil should have a correspondingly high fire test. The flashing point should not fall below 400 degrees Fahrenheit in any case; and the more animal fat the lower the fire test which ordinarily calls for from 500 to 600 degrees Fahrenheit. It is most difficult to obtain a much higher test. Although cylinder walls of an explosive engine are cooled with water jackets, it is nevertheless a fact that the lubricants are subject to the evaporative effect of the intensely hot gases. To withstand this successfully an oil of high fire test is required, and for general use a pure mineral oil is the best.

For compressor work the cylinder lubricant must withstand not only great heat or cold but, probably, ammonia influences. This means either a high fire test or a low cold test, or both; and the purely mineral oil fulfils these requirements. If ammonia is used it is imperative that only pure mineral oils be used, since any animal oil in conjunction with ammonia will form soap, which in turn will cause no end of trouble in the machine and the condensing coils. Another mineral that is regarded as a good cylinder lubricant is graphite. In a finely divided or flake form it gives an exceedingly smooth skin to the metal-rubbing surfaces and at the same time considerably lowers the coefficient of friction. The main trouble with the use of graphite formerly lay in the fact that it could not be fed into the cylinder like oil, and it could not reach all the surfaces that needed lubrication. This disadvantage restricted the use of graphite for a long time to special cases for emergencies. At first an attempt was made to mix the graphite with the cylinder oil so as to get it into the cylinder at the required points. The difficulty met with, however, was that the graphite would not stay mixed with the oil and would settle to the bottom, in which case it became not only useless as a lubricant, but very troublesome. After much experimenting this difficulty has been overcome by the application of a new principle in the mixing of the graphite and oil.

Properly speaking, two oils are used at about the same specific gravity, but of such natures that they will not mix together, as oils usually do; that is, they repel each other somewhat as do water and oil. In one of the oils, called the developing oil, the graphite is thoroughly mixed and ground until every particle of the graphite is surrounded and incased by a film of oil. This mixture is added to the other oil and the grinding and mixing continued, until the distribution of the graphite is complete and uniform throughout the mixture. It has been found that this compounded lubricant works well in cylinders if properly mixed, with the right quality of oils.

In conclusion, it should be said that there is no part of an engine where so much risk is taken in changing lubricants as in the cylinders. Therefore, it is advisable, where a lubricant is giving good service, not to change a certainty for an uncertainty.

Hudson-Fulton Celebration

We have received a synopsis of the plan and scope of the Hudson-Fulton celebration, which will begin on September 25 of this year and will continue for eight days in and around Greater New York and the following week in the cities along the Hudson river, as far north as Troy, with general participation throughout the State. It will surpass anything ever attempted in any city of the Union.

The commission in charge of the celebration is incorporated and consists of 365 members appointed by the governor of the State of New York and the mayor of the City of New York. Its membership includes the mayors of all the 46 cities of the State and the presidents of 38 incorporated villages along the Hudson. The president of the commission is Gen. Stewart L. Woodford, 18 Wall street, New York, and the presiding vice-president (also acting president) is Hermann Ridder, 182 William street. The headquarters is in the Tribune building, where the secretary, Henry W. Sackett, is to be found. The treasurer is Isaac N Seligman, 1 William street, New York City

The purpose of the commission is to arrange for the celebration of the three-hundredth anniversary of the discovery of the Hudson river by Henry Hudson, in 1609, and the one-hundredth anniversary of the successful application of steam to the navigation of the river by Robert Fulton in 1907. Because the two historic events occurred on the same river and their anniversaries came so closely together, it was deemed advisable to postpone the 1907 anniversary and celebrate both together.

The plans for the celebration have been formulated with a view to the international, national, interstate, State and local significance of the events to be commemorated.

Saturday and Sunday, September 25 and 26, will be religious-observance days; Monday, September 27, will be reception day; Tuesday, September 28, will be historical day; Wednesday, September 29, will be general commemoration day; Thursday, September 30, will be military-parade day; Friday, October 1, will be Hudson river day; Saturday, October 2, will be general carnival day in New York City.

In all the cities, October 2 will also be Children's Day, devoted to fetes in public and private parks and playgrounds.

The upper Hudson week, which will begin Sunday, October 3, will be somewhat in the nature of an Old Home Week. Each county has been assigned a day, as follows: Dutchess county, Monday, October 4; Ulster county, Tuesday, October 5; Greene county, Wednesday, October 6; Columbia county, Thursday, October 7; Albany county, Friday, October 8; Rensselaer county, Saturday, October 9.

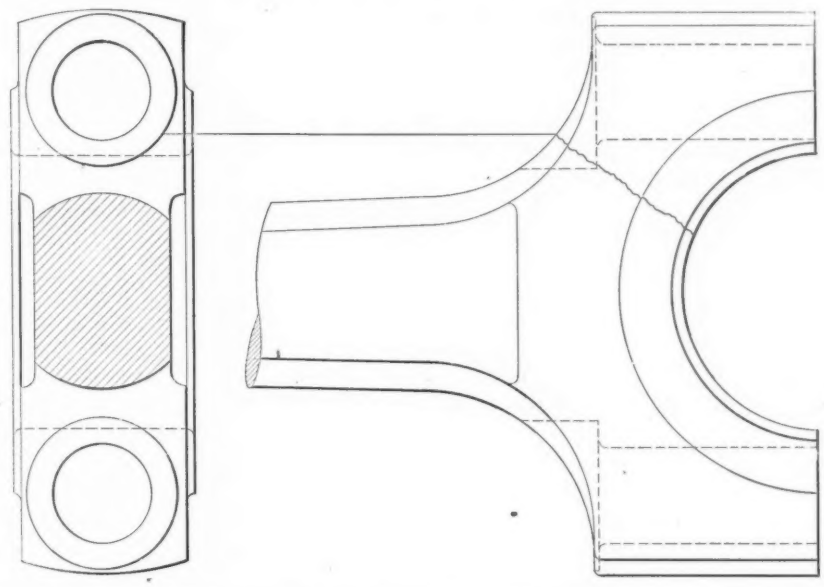
Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Connecting Rod Design

The accompanying illustration shows the end of a connecting rod which fractured in service about as indicated. The side view of the rod presents an appearance of great strength, which on closer inspection is found to be misleading. The shaft blends into the enlarged end with a curve of large radius, but the good effect of this construction is neutralized by the recesses for the bolt heads, which are of such large diameter relative to the width of the rod end that but a slight amount of metal is left on each side to reinforce the weak section.



SHOWING THE FRACTURE IN A CONNECTING ROD

A thin wall of metal such as this, introduced for the purpose of strengthening a heavy member, in many instances does more harm than good since, while it increases the stiffness of the member, it may for that very reason render it less able to resist shock. The stress developed will be high in the thin portion, and may cause a crack which would not have occurred but for the presence of such a thin web.

In this instance the bolts were made quite large, for the reason that they had been giving trouble by breaking frequently, the break occurring under the head and not, as might have been expected, at the root of the thread. Bolts for such service as this should be made of tough, refined wrought iron or nickel steel, and should be annealed at frequent intervals.

The drawings from which this rod was made showed the cap and bolts in position, the weak spot being then less evident than in the present illustration, where there are no accessories to detract attention from it, which goes to show that an assembly drawing is not always the best from which to study the proportions of parts.

GERALD E. FLANAGAN.

Pittsburg, Penn.

Chute for Handling Wood

I can suggest to I. B. Sutton a scheme which I have found very successful. Make a chute, about 500 feet long and 6 feet wide, into which the wood is delivered. As the lower sticks are removed, the wood will keep sliding down.

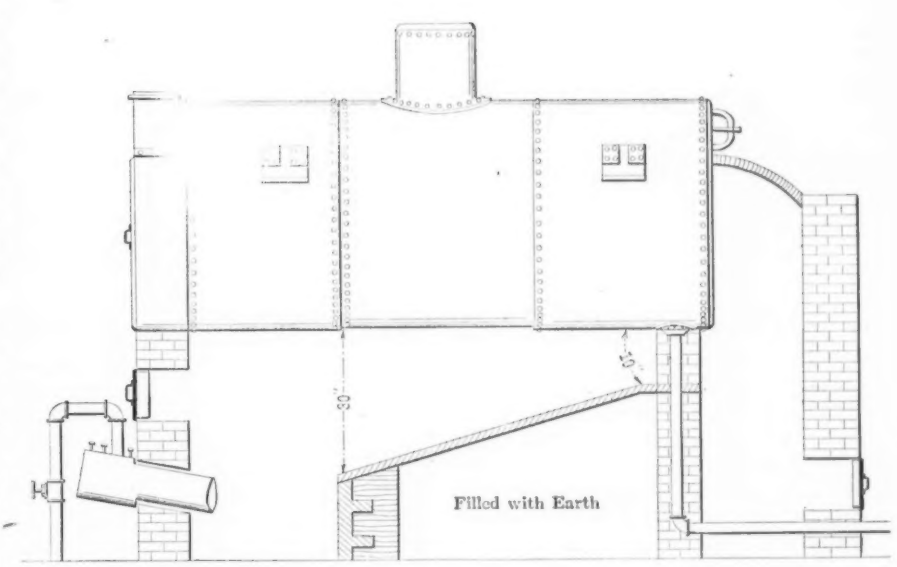
The great expense would be the grading of the wagon road to the top of the chute, and the cost of the chute, but it would soon pay for itself.

W. H. H. PLOWMAN.

Philadelphia, Penn.

Boiler Setting

The sketch shows the setting of a boiler in a plant where I am employed. As originally set, considerable smoke and soot were produced on the bottom of the boiler and in the flues. We installed two different types of gas burner, but could get no adjustment that would entirely eliminate the smoke. Finally the setting was changed as shown, and since



MR. ROBINSON'S BOILER SETTING

making the change the smoke and soot have disappeared.

I am not in a position to state the amount of gas that has been saved, because the boiler is connected on a 6-inch main with a number of other burners. However, it is safe to say that there is a saving of gas because of the more perfect combustion.

C. S. ROBINSON.

Independence, Kan.

An Emergency Packing Ring

The packing ring gave way in a Corliss engine, with no new ones nearer than the factory, and the engine was needed very badly. The type of ring is shown in Fig.

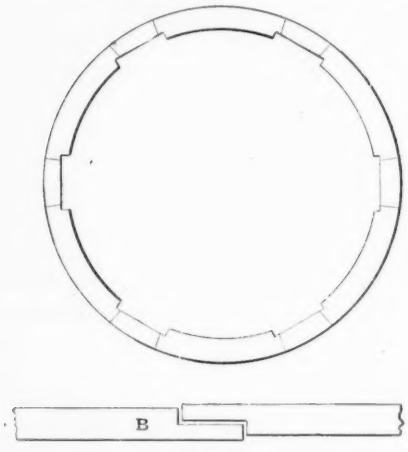


FIG. 1

1. Such a ring is placed in the slot of the bull ring, and held against the action of coil springs by small pins, which are inserted through holes in the rim of the bull ring, and also pass through holes in the packing ring (not shown in the sketch). These coil springs press outward against a tee-shaped piece of iron,

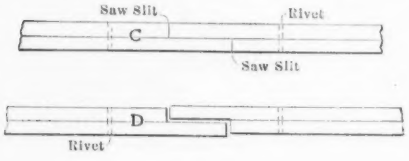


FIG. 2

the stem of the tee being inside the coil spring and the cross piece pressing against the slots shown on the inner surface of the ring. At *B* is shown how the sections overlap, making a steam-tight joint.

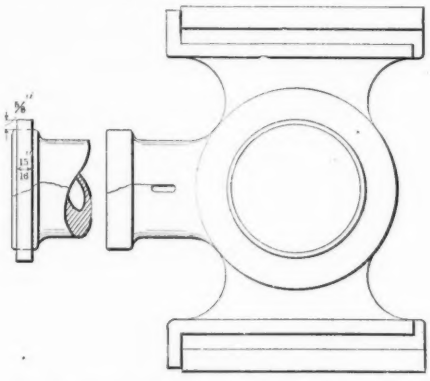
To make such a ring as is made at the factory is difficult, but a substitute may be easily made as follows: Two rings are bored and turned to the proper diameter for the finished rings, and the sides machined perfectly true. The two rings are then riveted together forming a single ring. At least two rivets should be placed in what is to be one section of the ring. The ring is then cut with a hacksaw, as shown at *C*, Fig. 2, after which the different sections may be separated as shown at *D*. Slots should be cut on the inner surface of the ring before the ring is sawed into its different sections. Holes should be drilled in the proper places to receive the pins for holding the ring in position on the bull ring while it is being placed in the cylinder. It is hardly necessary to state that after the bull ring is in place the pins must be removed to allow the springs to force the packing ring outward against the cylinder walls.

C. L. GREER.

Handley, Tex.

Crosshead Repair

The accompanying sketch shows the method employed by which a cracked



HOW A CRACKED CROSSHEAD WAS REPAIRED

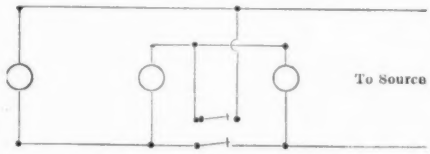
crosshead was repaired. The band, which was made of swedish iron, was, after being finished on a lathe, $\frac{5}{16}$ inch wide, $\frac{5}{8}$ inch thick and of $6\frac{13}{32}$ inches inside diameter. It was made with $\frac{3}{64}$-inch shrinkage fit and put on hot.

C. D. DISPENETTE.

Greenville, O.

Throwing Lamps in Series and in Parallel

On page 71 of the January 5 issue, E. J. Williams asks for a diagram showing how to throw three lamps from series to parallel and *vice versa*. The accompanying diagram indicates a method using only one double-pole single-throw switch



MR. DURAND'S SUGGESTION

which, on closing, connects the lamps in parallel and on opening puts them in series.

W. L. DURAND.

Brooklyn, N. Y.

I am submitting two wiring diagrams by which three battery lamps may be switched from parallel to series and *vice versa*, by means of standard switches.

The diagrams are the same except that in Fig. 1 two four-point pole-changing switches are used, while in Fig. 2 two double-pole double-throw knife switches are used. In both cases l_1, l_2 and l_3 are battery lamps; *S* and *S* are the switches. Fig. 1 shows the lamps in series using the pole-changing switches; Fig. 2 shows them in multiple, using the knife switches; *a* and *b* are common wires between the lamps.

This arrangement of wiring, for automobile sidelights and taillight makes it possible to economize on battery current while the machine is standing at the curb on the street.

It is required by law and is necessary,

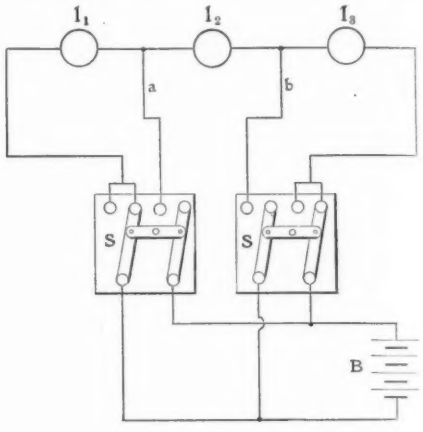


FIG. 1

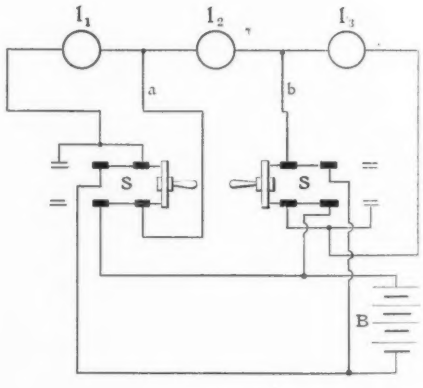


FIG. 2

to prevent accidents, to have these lights burning. When the lamps are thrown in series they draw only one-third the amount of current as when in multiple; however, the candlepower is reduced in the same proportion, but it is only necessary to have a light even though it is not brilliant. A special lever switch mounted on the dashboard of the automobile would be ideal for this wiring scheme.

J. E. WASHBURN.

Cleveland, O.

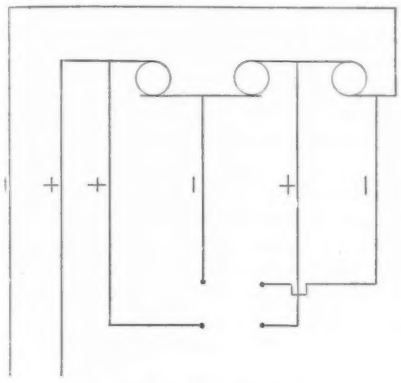
I think the sketch herewith will solve Mr. Williams' problem, using the same source of current. If he wishes to use two

different currents, however, he may employ a double-point double-throw knife switch. The switch shown in the sketch is a double-point single-throw switch.

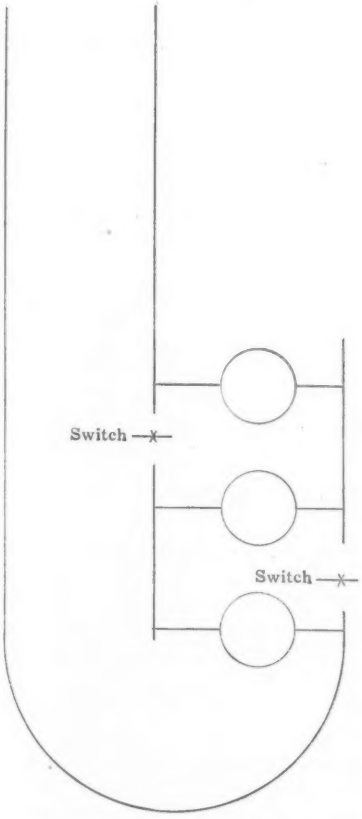
JAMES F. DRYDEN.

Pocomoke, Md.

I inclose a rough sketch of a method



MR. DRYDEN'S SOLUTION



MR. BENJAMIN'S DIAGRAM

which could be extended to any number of lamps, but would evidently be most desirable if only a few were needed.

As shown, the lamps are in series; if the switches were closed they would be in parallel.

C. A. BENJAMIN.

Philadelphia, Penn.

Effect of Scale in Boilers

If the furnace temperature of boilers averages 2000 degrees Fahrenheit, it is quite clear that the escaping gases would be 240 to 300 degrees higher before scaling than after scaling, if it were true that the scale caused an increase of from 12 to 15 per cent. in fuel consumption; otherwise, as Hilton Williams inquires, where does the extra heat go? It is very certain that 1/16-inch scale does not cause any such rise in temperature of escaping gases, and that the direct effect of scale on fuel bills is small.

But there is no justification for letting scale form in boilers, as all the deterioration and repairs to boilers arising from scale can be prevented, and all the labor of scaling boilers avoided, by the use of an open heater fitted with accessory soda treatment, whereby the scale-forming impurities are arrested at nominal cost, so that the boilers can be cleaned by merely washing out with a hose.

We have installed large numbers of such heater-softeners, with the greatest success with all types of boiler, so that no occasion arises for the use of boiler compounds or tube scrapers, but the fuel saving due to heating the feed with exhaust is far more important than the fuel saving arising directly from scale prevention.

ERITH'S ENGINEERING COMPANY, LTD.

London, England.

Commutator Trouble

In reply to A. L. Baker's letter for commutator advice, I will suggest a few causes that could produce his trouble. It is understood that the smallest details are fully known, but in nine cases out of ten that is where the trouble is found. As he does not say what his load is when the bad sparking occurs, I take it for granted that he is carrying the full load.

As the machine was designed for 250 volts, and only 220 volts are being carried, the proper field density is not obtained. The speed should be cut down and the field current increased. If the brushes are radial, see that each set are perfectly so. If they are angle brushes and the commutator runs against the toe, take the holders off the studs and reverse them, making the commutator run against the heel of the brush. See that there are the same number of commutator bars between the sets of brushes, and adjust the rocker arm to get the proper lead for sparkless commutation. No amount of adjusting will help if the trouble is in the brushes. Have the brushes work free in the holders and do not have them too long. A brush a little too short will work better than one too long. Adjust the tension on the brush springs to hold the brush snug to the commutator. If the bus voltage drops at full load, adjust the shunt resistance to get the correct compounding.

From the nature of the trouble, I should not think it was in the armature; however, it would be well to test for opens and grounds, if such has not been done. I am inclined to think the trouble is a weak field, if the brushes and lead are absolutely correct.

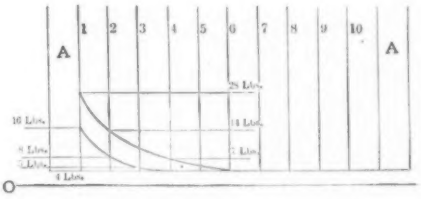
L. E. BROWN.

Ensley, Ala.

Compression

I have often read articles for and against compression as a means of economy in the use of steam. Some engineers say they have tried it, but they do not show indicator diagrams taken with no compression, while they do show diagrams taken with what they call medium compression. I judge by these diagrams that engineers are inclined to expect too much from a slight change in the closing of the exhaust valve, say 2 or 3 inches before the end of the stroke.

The accompanying sketch shows very plainly what may be expected at two points of closure. I divide the cylinder into ten equal parts, and assume one of those parts to be equal to the clearance



FOR DETERMINING COMPRESSION

and steam passages, designated by the spaces *A A*.

In practice the exhaust pressure is, say, 4 pounds above the atmospheric line *O*. Suppose the exhaust valve closed at three-tenths before the end of the stroke; the pressure would be 16 pounds when the piston has arrived at the end of its stroke. The pressure at the first and second points is also shown. What might be expected if the exhaust valve closes at one-half stroke is also shown.

Taking this as a standard of comparison for the compression end of an indicator card, how do the cards generally illustrated compare? They do not show compression to an extent that would show any difference in the consumption of steam, for they do not raise the pressure more than 3 or 4 pounds by compression alone. Some flywheel governors that advance all of the points, that is, compression, admission, cutoff and exhaust, show compression very prominently.

J. F. KINGSLEY.

Athens, Penn.

Do Crank Pins Always Wear Flat?

An old crank of the center-crank type was brought into the machine shop. It had evidently been in use for a long time, for the crank pin was worn so small that the owner felt that it was no longer safe. One of the men measured the crank with

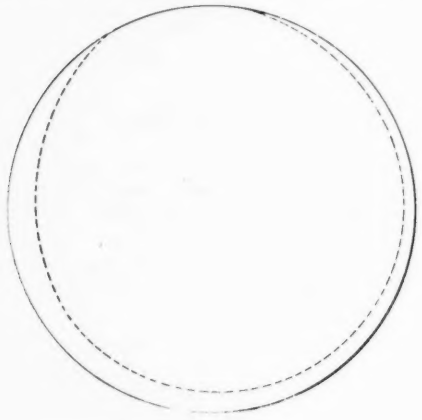


FIG. 1

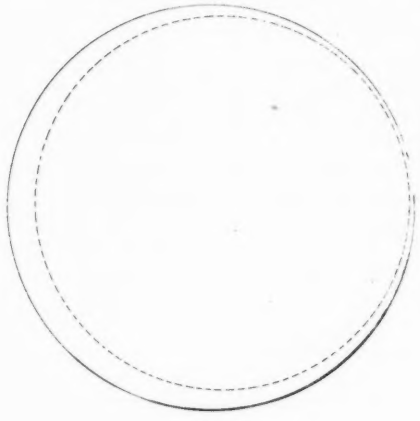


FIG. 2

his calipers and then told another of the men to measure the flat spots on the pin and tell which way the crank turned.

That seemed tolerably easy to do, and the man took his calipers and went to the crank. A glance at the pin and bell showed which side of the pin received the pressure, for the pin was badly out of center with the bell, but the most careful calipering failed to show that it was out of round; neither could any flat spots be found.

In a discussion which had taken place about the wear of crank pins, the apparent fact that pins would always wear out of round had not been questioned, but the talk had been confined to the ultimate shape and position of the results as compared to the original position of the pin. The same question came up in another place some time later. A crank pin was examined that measured 3/8 inch closer to the bell on one side than on the other, and yet this pin was round as far as the ordinary measurements could detect.

The usual assumption is that crank pins should wear flat, and the assertion is often made that they do wear flat in steam-engine practice. The cranks referred to were from small steam engines of not over 40 horsepower, but for some reason they were round.

If it is proper and natural for a steam-engine crank pin to wear flat, it would seem even more natural and proper for a gas-engine crank to do so. I measured some worn gas-engine cranks to see how they wore. One from a 40-horsepower engine had been in hard service for about four years. It had run dry, had become cut several times and had been redressed by filing. It was practically 1/4 inch smaller than when new. Two experts measured it carefully with a micrometer and pronounced it out of round not to exceed 0.002 of an inch.

One from a 20-horsepower gas engine had been in use for thirteen and one-half years. Measuring with a scale from the pin to the washer that had been faced on the bell to give the brasses a bearing showed that the pin was a full 1/8 of an inch nearer to it on one side than it was on the other, yet the micrometers showed that the pin was round within 0.0015 of an inch. This pin was 7/32 smaller than the original size.

A crank from a 15-horsepower gas engine had been in use more than ten years. It was more than 1/4 of an inch smaller than the original size. It was 3/32 of an inch removed from its original center and was practically round, being out but 0.001 of an inch. These pins had not been carefully used and should have shown the effects of wear in a marked and unmistakable way.

It takes constant attention and careful work to have pins turned on center-throw cranks so perfect that the micrometer will not find any variation from round. Pins were measured on cranks where the engines had always received good care, and where there were no signs of cutting, and they were found to be round. Pins have been pronounced out of round by men who were not skilled in using measuring instruments, when experts found the trouble in the men and not in the cranks.

Pins from side-crank engines, if taken out and revolved on the original centers, often will not run true where the brasses bear, but this does not prove that they are not round there any more than it would prove that an eccentric is not round because it does not run true when put on a mandrel that causes the hole to run true. It may be that crank pins on larger or smaller engines than these mentioned will show different results, and it may be that engines designed differently may also do so, and if such is the case it will be interesting to know it.

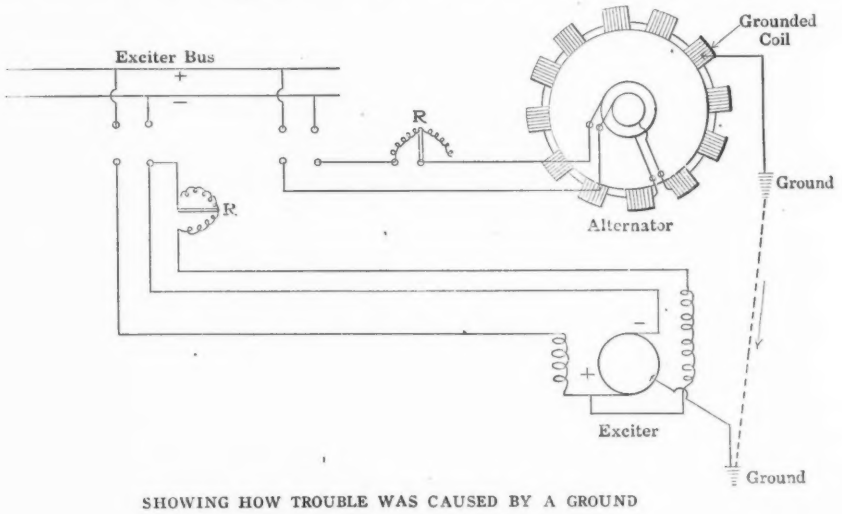
In Fig. 1 the full circle represents the original pin and the dotted lines represent the shape it was thought it would assume from wear and its position in relation to the original. In Fig. 2 is shown in outline the original pin, the dotted circle representing the pin, which has been worn round but not flat.

W. O. PLATT.

Oil City, Penn.

Trouble Caused by a Ground

The equipment in the generator room of a paper-mill power plant consisted of three 500-kilowatt three-phase 440-volt revolving-field alternators, direct-connected to water turbines. The alternator shafts were extended for driving the exciters and various other machinery. There were two 37.5-kilowatt exciters, belt-driven. No. 1 alternator carried No. 1 exciter; No. 2 alternator carried a low-pressure centrifugal pump, direct-connected and a high-pressure power pump, belt-connected; No. 3 alternator carried No. 2 exciter and the mate to the centrifugal pump. To complete the "mess" there was a gallery switchboard stuck up under the roof and a spiral stairway lead-



SHOWING HOW TROUBLE WAS CAUSED BY A GROUND

ing to it. One night I went to the generator room and found the attendant acting rather dizzy. I first thought he had got a series of hurry calls up the winding stairs, but a whiff of his breath was sufficient proof that the stairs were not wholly to blame.

Soon after taking charge I found that the commutator of No. 2 exciter was damaged in a rather peculiar manner, the insulation between the bars being burned all around the outer end, and extending from one-fourth to one-third the length of the bars. A test showed the armature to be grounded and the commutator ran too warm, but the machine generated all right.

One Sunday morning the attendant wished to shut down No. 1 alternator and, therefore, changed over to No. 2 exciter. Soon after doing so he noticed that No. 2 alternator was vibrating back and forth on the base with each revolution of the field. My first impression was that the anchor bolts were loose, but a trial with a wrench showed them to be tight.

As the exciter was known to be grounded, I started testing the alternator field circuit for a ground, and discovered that about one-third of the field coils were warmer than the others. The circuit was then broken between the cool coils and the warm ones and a test showed the ground to be among the cool ones, and the first cool coil proved to be "it." When the coil was removed it was found that the insulation, although very heavy, had been punctured and a hole as large as a quarter of a dollar burned in it, thus grounding the coil on the pole piece.

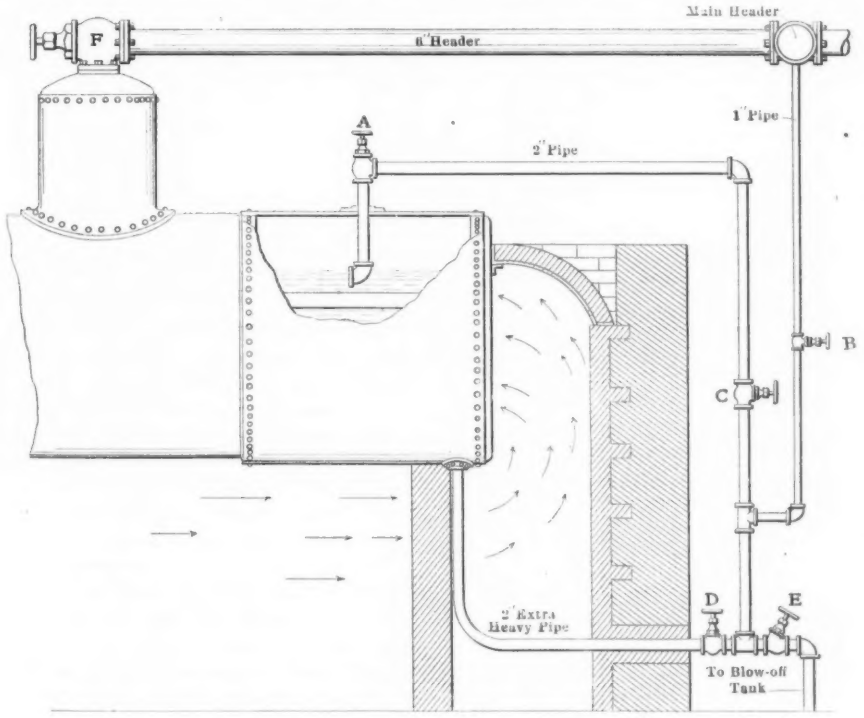
The sketch (on page 290) shows how the trouble occurred. The grounded exciter and grounded coil short-circuited some current from a part of the coils, making them weaker than the others. Undoubtedly the primary cause of the trouble was that at some time the field insulation had been punctured by inductive discharges, and the grounded exciter did the rest.

H. L. Strong.

Portland, Me.

A Blowoff Arrangement

The sketch illustrates a blowoff arrangement I have been using for five years. At *A* is a 2-inch angle valve on the scum blowoff, to be used in case of repairs on the blowoff valve. The scum blowoff leads into the boiler at the top and extends down just below the normal water line, with an ell facing toward the front of the boiler. At *D* is a 2-inch gate valve, and at *E* a 2-inch Y-valve.



SHOWING MR. FINLEY'S BLOWOFF ARRANGEMENT

While the boiler is in use the valves *B*, *C* and *D* are open, and valve *E* is closed. When I blow off the boiler, about every six hours, I close valves *B* and *C* and open valve *E*. When I have blown down enough I close valve *D*, open valve *C* and blow off the scum; then I close valve *C* and open valve *B* in the line leading to the main steam header.

With *B* open, I get practically dry steam, and the circulation in the blowoff pipe removes any mud or particles of scale away from the disk of the valve *E*. With valve *B* open, valve *E* closed and valves *C* and *D* open the condensation in the steam header flows through the 1-inch pipe by gravity and back to the boiler through the blowoff, which causes circulation enough to keep the blowoff pipe clear of mud, etc. I have not been troubled with the blowoff being stopped up in the last five years, and I do not have to renew the disk in valve *E* oftener than once a year. I am using the arrangement on two 125-horsepower return-tubular boilers.

S. R. Finley.

Buffalo, N. Y.

Rocognizing the Staff

The editorial, "The Line Recognizes the Staff," on page 174 of the January 19 number, is in keeping with the average marine engineer's view of the matter. "Fighting Bob" Evans certainly deserves no little credit for forgetting the usual standing of the navigator so far as to admit that "the man who brought the fleet around the Horn is the man who boiled the water in the fireroom and the man who peeled the potatoes." The effect of this munificent statement is to a certain extent spoiled, however, by the additional remark that "they have done as much to take it, step by step, as the keen-eyed officer on the deck or the gray-haired captain on the bridge." It would have been more in keeping if the admiral had compared the men boiling the water and peeling potatoes with the men on lookout and at the wheel. Other comparisons could have followed.

Who can explain the antagonism which exists between officers of the deck department as a whole and those of the engine department? Is it that the deck officer lived and had his being centuries before steam propulsion was thought of? Can it be that it exists because the engineer is in a position to command a salary in keeping with his increasing responsibilities and is at present much better paid? Then, again, it might be the engineer's natural aggressiveness that is to blame, or the fact that the engineer's uniform when on duty is a suit of overalls.

That the captain of a vessel making an exceptionally fine run is lauded and feted is due, to a great extent, to the fact that the newspaper man and reporter seldom see the chief engineer, and, at best, can get little information in that direction, whereas the deck officers are easily reached and are not so averse to talking. Engineers do occasionally get credit, however, as in the case of a recent happening in New York harbor, when one of the leading papers referred to the quickness of the captain's eye and the smart work of the engineers at the levers as the means of saving a ship. So let us be thankful for small mercies.

I want to relate a little incident that happened on my ship not so long ago:

We were hustling through the usual routine of boiler-room work in port. There were men cleaning smoke boxes, others wheeling ashes to the hoists, some

at work on the furnaces and the hundred other jobs requiring doing in the short time the ship would be in port. Needless to mention, all was noise, dirt and seeming confusion, and myself in the thick of it. As the men were preparing to swing open another smokebox door I was surprised to see them hesitate and look over my shoulder and on turning was even more surprised to see the third mate, Mr. Smitzer, standing watching operations in the company of a stranger. This third mate was one of those men who, having failed in the battle of life, are fond of telling yarns of the time they were "in command," and have no little idea of their importance. He condescended to recognize my presence with a brief nod. I noticed one of my men at this point mutter to his mate and they both grinned maliciously. It occurred to me that Mr. Smitzer had had this same man logged for throwing some scraps of food in the scuppers.

On a question from the stranger Mr. Smitzer approached me with a supercilious air. The conversation that followed was interesting.

"How many boilers have we, Mr.—er—er?"

"Six." This from me.

Smitzer, turning to the stranger, who was listening to my answer, said: "We have six boilers!"

"And, how many fires in each boiler, Mr.—er—er?"

"Eight." This to the stranger, who originally asked the question.

"We have eight fires to each boiler!" This from Smitzer, impressively.

"How many men are on duty at a time?" asked the stranger, pleasantly.

"How many men have we on duty at one time?" anxiously parroted Smitzer, getting ready to enlighten the stranger in my stead.

"Twenty-four."

"We have twenty-four men on duty down here at one time. Think of it! You see," explained the garrulous Smitzer to the stranger, "we have to drive her all the time!" *We* have to!

At this moment the stranger walked across the boiler room to look into the uptake of a clean boiler, Mr. Smitzer staying behind to gaze around him with arms akimbo. Suddenly a startled yell rang out and the stranger and I turned in time to see a great stream of ashes pour from the opened smokebox. The air was filled with ashes and soot at that end of the boiler room and in the midst of it all scrambled the unfortunate third mate.

Of course, I saw to it that the men were severely spoken to, and that some of the ashes were removed from Smitzer's clothes before he returned to the deck. What is the moral? Why, there are several of them.

B. SLATTERY.

New York City.

Some Vertical Centrifugal Pump Troubles

We have a vertical, centrifugal, belt-driven pump in our plant, used for circulating water. As the sand which freely mixes with the water is very sharp, the casing of the pump is provided with removable liners in order to protect the interior. These linings have to be renewed every six or seven months.

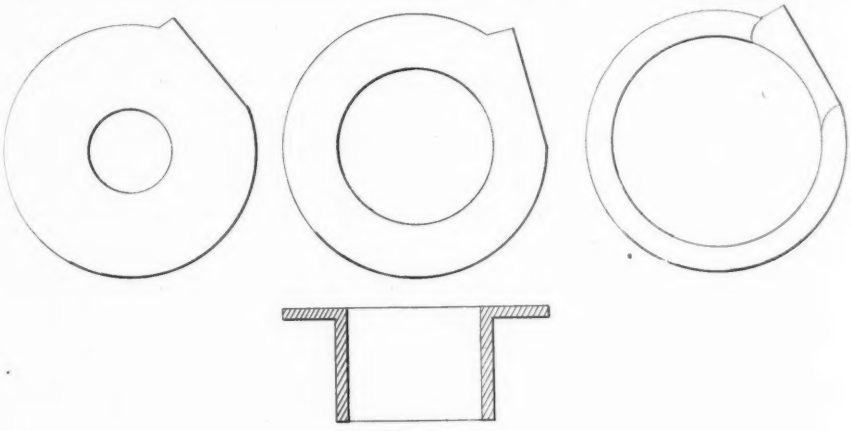


FIG. 1

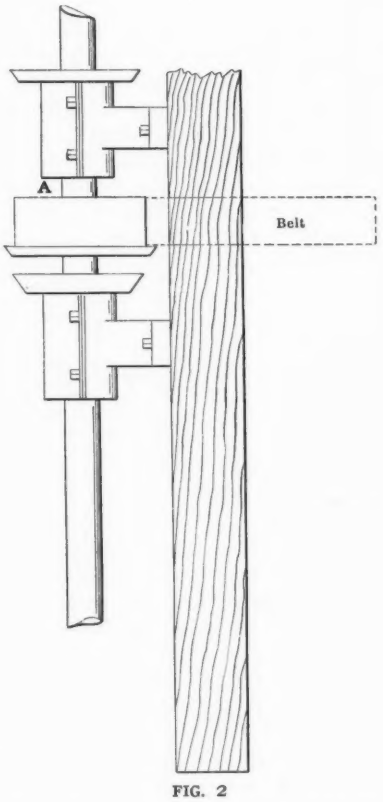


FIG. 2

Referring to Fig. 1, the first two liners are the protectors for the top and bottom of the casing, while at the right is a ring for protecting the sides.

One of the most common troubles with this type of pump is that it may not throw enough water, due to a slipping belt. The pulley on the shaft of a vertical centrifugal pump is usually placed between two shaft bearings, as shown in Fig. 2. If the operator is careless and puts too much oil in the top bearing the oil will run to the pulley, then onto the belt, causing it tc slip, and ruining the belt. In order to prevent this trouble we put an oil guard around the shaft at the lower part of the top bearing as at *A*.

At one time the pump failed to pick up water. After disconnecting a flange in the discharge pipe it was found that the pipe was full of sand to the end of the outlet. As there was not ample pressure in the pump to force the sand out of the pipe, it was not able to pick up.

A common trouble experienced with vertical centrifugal pumps is that the impeller will work down, due to the support holding the shaft and impeller wearing or working loose, when the bottom side of the impeller will rub against the lower lining plate, thereby wearing this lining and lower part of the impeller out in a short time, besides causing more friction, which takes more power.

We have a gage at a convenient point on the vertical shaft by which we can see when the impeller is going too low, when it is adjusted again. Here is where an electric motor would be the thing for driving a vertical centrifugal pump, because should the impeller work down too low and rub against the lower lining, or any of the bearings wear, or be carelessly adjusted and out of alinement, the increased friction would be indicated at once by a meter connected to the motor.

H. JAHNKE.

Milwaukee, Wis.

Neatsfoot Oil on Belts

In the January 5 number, page 70, Charles Haeusser writes regarding the detrimental effect of neatsfoot oil on belts. We have seven belts in our plant, ranging from 4 inches to 22 inches in width, and neatsfoot oil is applied to each with gratifying results. It is in my opinion the best belt dressing one can use.

JOSEPH H. JACOBUCCI.

Rawlins, Wyo.

New Method of Equalizing Cutoff

The two sets of diagrams shown in Figs. 1 and 2 were taken from the same Corliss engine. Fig. 1 was taken with the governor as sent out with the engine; Fig. 2 was taken after I had put my improvement on. It will be seen that an even cutoff is obtained on both ends of Fig. 2, even with a variable load.

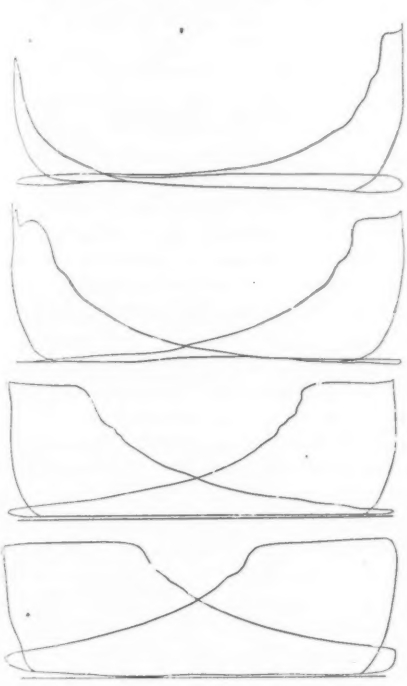


FIG. 1

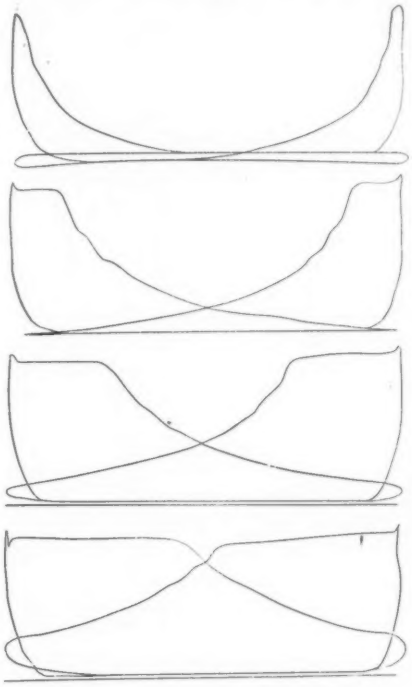


FIG. 2

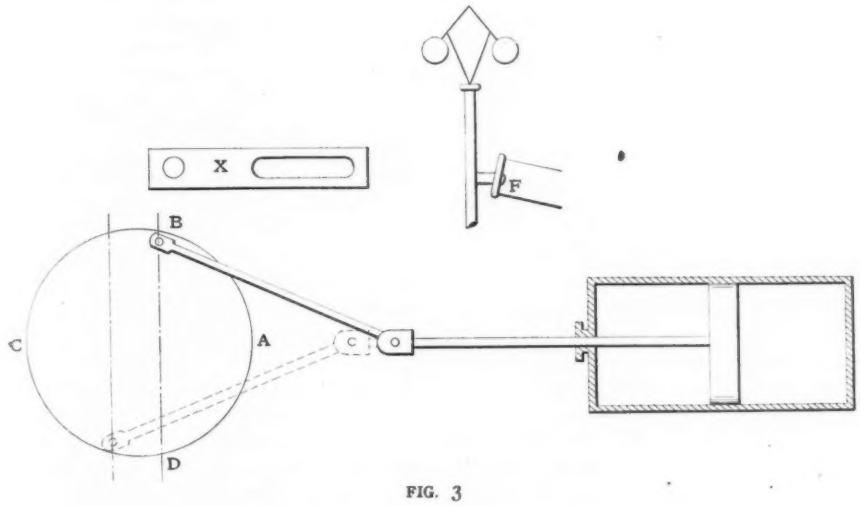


FIG. 3

By referring to Fig. 3, it will be seen that when the piston is at half stroke the pin has traveled from *A* to *B*, and the eccentric has moved the same as the pin, not quite 90 degrees, due to the angularity of the connecting rod. On the return stroke the pin travels from the outer center *C* to *D*, in order to place the piston at half stroke. The eccentric has traveled a greater distance on this return stroke, as when the pin is at *E* the eccentric has moved the same distance as when on the outstroke from *A* to *B*, but the piston would not be at half stroke, as shown by the dotted lines. To overcome this difference in the eccentric travel the crank-head valve must be left open longer at full load and close sooner at light load.

In order to do this I lengthened the lower end *F* of the governor rocker arm operating the cam of the crank-end valve. To determine the length I took a piece of iron, as shown at *X*, about ⅛ inch thick by ¾ inch wide and 3 inches long, and drilled a hole in one end to bolt to the arm, and a slotted hole in the other in which to attach the reach rod. By taking a diagram with a light load and one with a heavy load, I determined the proper length and then had a new rocker arm cast and fitted to replace the old one. The longer the connecting rod to the engine, the less is the angularity, and the less should the arm be lengthened. In my case the arm was made 1⅝ inches longer than the original rocker arm.

G. D. LIVINGSTON.

Minneapolis, Minn.

Municipal Ownership

The editorial entitled "Municipal Electric Light Plants," in the issue of December 29, seems to have been written on the assumption that the conditions under which such plants are built and operated are ideal—or can easily be made so.

Those who are most familiar with municipal plants know that so far from this being the case the actual conditions are such as to put the municipal plant at a serious disadvantage in comparison with private plants. This is the case even if graft be left out of consideration.

The business men of a city may *discuss* municipal ownership as a business proposition, but as soon as it passes from the field of discussion into that of construction it passes at the same moment from the domain of business into that of politics. There lies the weak point in your argument. The affairs of our cities are not conducted in a business-like way, and until they are all municipal undertakings will be heavily handicapped both by red-tape methods and political considerations. This is admitted freely by everyone who has occupied a municipal office and whenever a business man has had a term of office he has inevitably emphasized the unbusiness-like conditions which he has found to prevail in the conduct of municipal affairs. Red-tape methods are responsible for the well known fact that, even where there is no graft, the construction of a municipal plant costs from 10 to 100 per cent. more than that of a private plant of the same capacity. This extra cost starts with the purchase of the land, follows through each stage of the construction and equipment, and much more than offsets the slightly lower rate at which cities can borrow money. But it is not merely graft in its usually accepted sense, nor "honest graft," but favoritism and influence which are at work leading not always to criminal practices, but always resulting in the municipality paying more than a private party would pay.

Nor does red-tape stop when the plant is built. It affects unfavorably the cost of fuel and supplies of all sorts, and thus increases the operating expenses above those of a private plant.

The political considerations are more far-reaching in their injurious results. The acceptance of plans, the making of contracts, and the employment of labor are in the hands of councils, the members of which start with no knowledge of the business, and usually remain in office too short a time to acquire more than a superficial knowledge.

The manager, to start with, is apt to owe his appointment to his political activity quite as much as to his technical and executive ability, and this is to be expected; or if this is not the case, he knows that a change of administration may bring his career to a sudden and undeserved end. His salary is always lower than it would be under private ownership, and there is not the opportunity for promotion which exists in private companies. The best class of managers are therefore not permanently attracted to municipal plants, the proof of this statement being that municipal managers are constantly seeking employment in private companies, while there is no tendency the other way. It is not true, therefore, that municipal office attracts technical ability of the highest order; just the contrary is apt to be the case.

Similar considerations affect the minor employees in the same way all along the line with the result that cities rarely get the best class of workmen, and do not get as much or as good work per employee as do private employers. Most of them know that they are not employed solely on their merits, and act accordingly, especially as the power of summary and permanent dismissal is rarely in the hands of the manager, who, by the way, is properly called a superintendent rather than a manager. It is notorious that the productive capacity of a city workman is not usually over one-half of what a private business expects to obtain and does get.

If the employees, from top to bottom, are inferior to those of a private plant of like capacity, and take a less personal interest in their work, it follows that the plant will not be run at its greatest efficiency and economy, nor will the machinery receive the same care as in a private plant. This means that there will be larger bills for repairs, that operating expenses will be heavier, and that depreciation will be greater. And experience has shown that these expected unfavorable results are fully realized in all particulars.

You say that "graft, ignorance and incompetence are not inevitable" in city undertakings of this character. That is true; there are exceptions, but they are rare. But at least two of these three disgraces are prevalent in the great majority of our American cities; and until there is a complete revolution in our methods of city government, they will continue to be the almost universal rule. The cases are so few where municipal electric plants have been operated on business lines for any extended period that the editorial referred to seems likely to be productive of serious misapprehension on the part of such of your readers as are not familiar with the conditions that actually prevail in the great majority of such plants—conditions far removed from the ideal.

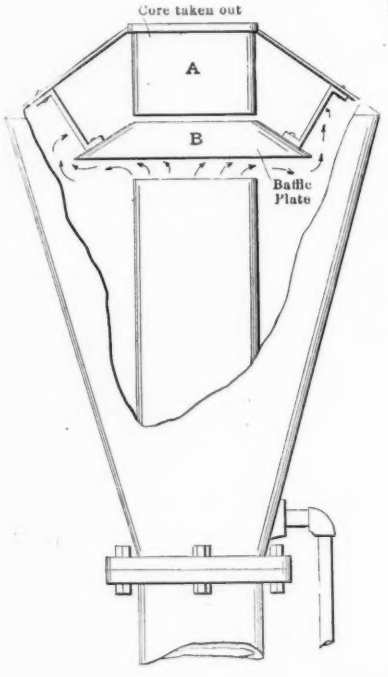
ARTHUR WILLIAMS.

New York City.

Reduced the Back Pressure

I once had charge of a plant having one engine, the indicator cards of which always showed a back pressure of 4 pounds when the back-pressure valve was up. In my hunt for the cause I examined the exhaust head and found the core *A* extended down to within ¼ inch of the baffle *B* (see illustration).

In this case, the exhaust pipe being 6



SHOWING HOW CORE IN EXHAUST HEAD INCREASED BACK PRESSURE

inches in diameter, the baffle plate should have been at least 1½ inches from the core *A*. I removed the core *A* and thus reduced the back pressure 3 pounds.

A. WALDRON.

Lynn, Mass.

Electric Discharges

In regard to George A. Raymant's article in the December 22 issue, page 1045, he will find that if he thoroughly insulates himself from the ground and stands in a cloud of steam issuing from a leak in a high-pressure steam pipe and brings his hand near the ground or pipe, he will invariably obtain sparks. If he will get in a dark place where steam is escaping from a pop safety valve or other large leak directly into the air, he will see a halo of sparks and blue light around the leak. In fact he will see a miniature thunder storm. In his case the calking chisel was the lightning rod and it was struck with miniature lightning bolts. The electricity is generated by the friction of the steam passing through the air.

HOWARD GLUYS.

Richmond, Ind.

Natural Gas for Fuel

I noticed an article in the December 22 number by W. D. Ranney, on natural gas for fuel, wherein he says he obtains a boiler horsepower on 27.95 cubic feet of gas. Now, 27.95 cubic feet of gas is equivalent to only 27,950 B.t.u., and a boiler horsepower is $966 \times 34\frac{1}{2} = 33{,}327$ B.t.u., hence his figures must be wrong. I am assuming Ohio natural gas to contain 1000 B.t.u. per cubic foot.

EDWARD H. LANE.

Kansas City, Mo.

Steam Piping

Having read the article, "Steam Pipe Connections," by Fred Dubell, on page 1099 of the December 29 number, I am led to call attention to that part of the article under the subhead, "Steam Pipe Should Drop Toward Boiler." This is a statement I challenge. As steam on leaving the boilers begins to condense, the water falls to the bottom of the pipe and is carried along with the steam, and it is impossible for the water to return to the boilers against the flow of steam.

I have in mind an instance of a ¾-inch vertical steam pipe 96 feet high, piped direct from a battery of boilers. This pipe ran horizontally for about 15 feet to an elevator shaft, then up 96 feet to a temporary bathroom. This pipe, contrary to expectation, always stood full of cold water, except when the valves were open at the upper end, although the boilers carried a steam pressure of 100 pounds.

In steam pipes dropping toward the boilers the water accumulates in slugs, and when the flow of steam is sufficiently obstructed it passes on to the engine cylinder, washing out the oil. Valves and valve seats are cut, also the cylinders and packing; piston rings are broken and engines are wrecked.

In twenty-five years' experience, several of which were spent in inspection service, I have never known an engine wrecked from water in steam piping, except when the pipe dropped back toward the boilers.

Steam piping should always drop toward the engine. When erected in this way the condensation is carried along with the steam, and even if allowed to go into the engine, does but very little harm. It is better practice to connect to the engine through a steam separator, or receiver, with a good steam trap to carry off the condensation. It is certainly safer, and better for an engine to operate with even wet steam all the time than to have a cylinder full of water occasionally and saturated steam the remainder of the time.

In practice the steam main dropping from the boilers to the engine in calorimeter tests always shows drier steam at

the engine than where the pipe drops toward the boilers.

T. J. Bloss.

Chattanooga, Tenn.

Combustion Formulas

In the December 15 number Mr. Neely contributed an article of real value. I have checked his charts with a number of analyses of my own, and some from various authors, and find that No. 2 chart gives results as accurately as samples can be taken in a mine.

The classifications attempted by the fuel-testing plant here at St. Louis showed that the hydrogen-carbon ratio was the most satisfactory one, and that fixed carbon alone was not reliable except in true anthracites. We used to have a rule-of-thumb method of estimating heating values for Mississippi valley coals, which was to add the fixed carbon and volatile percentages and multiply by 150. This gives too low results on the best bituminous coals and too high on the poorest.

Mr. Neely's chart is practically exact on coals of the Appalachian range, but varies somewhat in some of the Western coals. Unfortunately, the results as published by the fuel-testing plant give only two each of Colorado and Wyoming coals and these are among the poorest of the two States. For comparison I will quote three with which I have had some practical experience; two are from the past-carboniferous period of the Rocky mountains, and the third is a well recognized bituminous coal of Illinois:

	Rock Springs, Wyo.	Trinidad, Colo.	Big Muddy, Ill.
	Per Cent.	Per Cent.	Per Cent.
Moisture	5.55	1.32	7.50
Volatile matter	36.95	38.23	30.70
Fixed Carbon	55.70	55.86	53.80
Ash	1.80	3.59	8.00
Total combustible	93.65	94.09	84.50

According to Mr. Neely's table the combustion values would be, respectively, 14,000, 15,000 and 12,600 B.t.u., whereas the values given by the respective analysts are 13,240, 13,680 and 12,420 B.t.u. The explanation for the differences shown is that the volatile matter of the Appalachian coals is usually marsh gas (CH_4), and that of the Western coals is composed of oxygen compounds, which rob the volatile matter of a large part of its hydrogen in combustion. On the other hand, the Western coals make an excellent showing in gas producers, as the oxygen of the volatile matter is readily converted to carbon monoxide and their comparative freedom from ash and sulphur prevents the formation of clinkers. In the Wyoming coals of the southern field the sulphur content averages less than 1 per cent., and is usually present as gypsum instead of pyrite. Another characteristic is their hard structure which enables them to stand transportation and handling without crumbling. This is particularly noticeable in the Trinidad field, some of the coal closely resembling anthracite in appearance and hardness, though usually containing less than 60 per cent. of fixed carbon.

Kent's table, given by Mr. Neely, gives approximate results for most steam coals, but I do not like any estimates based on coal, dry and free from ash. It has been said that one could prove anything by statistics. The situation here in St. Louis is this: A representative coal of Illinois has a formula something like the following:

Moisture, 12 per cent.;
Volatile matter, 33 per cent.;
Fixed carbon, 41 per cent.;
Ash, 14 per cent.

This is not the best nor the worst coal in the State; in fact, its composition is about as fair an average as can be had. The sum of its combustible ingredients is 74 per cent., which makes it fall below Mr. Neely's chart, but its heating value per pound of coal is 10,580 B.t.u., so it falls in line with Mr. Neely's straight line, if it were extended. According to Kent's formula, by interpolation, it would have 13,680 B.t.u. per pound of combustible and 10,123 per pound of coal. The actual results show 10,580 B.t.u. per pound of coal and 14,600 B.t.u. per pound of combustible, a difference of nearly 40 per cent. The moisture and ash contents are 26 per cent., or one-fourth of the whole, or a total of 520 pounds in every ton which has to be transported and handled before it is delivered to the boilers, and again, 280 pounds of ash have to be raked out of the ashpit for each ton consumed, and, in a city, removed at a considerable cost. Yet on comparison of "heat units per pound of coal dry and free from ash," it compares favorably with hand-picked Buck mountain or Pocahontas coal.

The real test of a steam coal, from an economical point of view, is how much steam it will make for one dollar. Many look at the analysis of a coal to see what its fixed carbon content is, and gage its value by that. Theoretically this is a poor way, as a certain amount of volatile matter is an advantage, provided it can be completely burned. With the usual run of furnaces, though, a large amount of volatile matter is allowed to go to waste as chimney gases or soot, hence a classification based on fixed carbon is not so bad after all. The cheapest fuel that we get here in St. Louis is slack or screenings from the nearby mines. It has about one-third each of volatile matter and fixed carbon, and one-third waste in the form of moisture and ash. Its calorific value is about 8500 B.t.u., a little over one-half that of the best coals of the Appalachian range, yet it can be delivered at the boilers for less than one-fourth of the price of any Eastern coal. On the other hand, it requires a larger boiler installation and greater expense for the removal of the ash and clinker formed, and greater deterioration of the plant, so the net gain is not as great as might be supposed at first sight.

It has often been said that analyses of Rocky mountain coals, such as I have quoted, are those of picked samples and do not fairly represent the mine. In three years I took many samples of Wyoming coals and found the following range of contents: Moisture, 4 to 10 per cent.; volatile matter, 30 to 38 per cent., and fixed carbon, 52 to 58 per cent.; ash, less than 5 per cent.; sulphur, less than 1 per cent. One car of coal, or 88,000 pounds, burned under a return-tubular boiler yielded 1820 pounds of coarse ash, or 2.06 per cent.

LeRoy Baker.

St. Louis, Mo.

A 500 or 250 Volt System for Motors

The article under this caption, written by A. Chisholm, in the December 15 issue, must be very misleading, or else I have misconstrued his meaning. If he has intended his motor connections to be made to a 500-volt three-wire system, well and good; but if intended, as I imply, to be a common 500-volt system I cannot see that it is at all practical.

I would call his attention by way of friendly criticism to the all too common error of expression of electrical terms which appears in the second paragraph: "*C* and *D* are two ordinary starting boxes, such as would be used for motors running at any voltage." Now, there is no such thing as an ordinary starting box for any voltage. If you think so put, say, a 5-horsepower 110-volt starting box on a 5-horsepower motor using 500 volts and see how it works.

L. E. Brown.

Ensley, Ala.

The Modern Surface Condenser

Referring to G. A. Orrok's reply in the issue of December 22, page 1052, to Mr. Mueller's remarks on Mr. Orrok's surface-condenser article, Mr. Orrok states that he fails to understand how surface efficiency can be obtained by excessively large air pumps or the vacuum augmenter. To the writer this seems to require no explanation whatever, inasmuch as the surface efficiency depends to an enormous extent on the amount of air in contact with the tubes.

It is not so much a matter of how much the air pumps remove, but of the quantity they leave behind in the condenser, drowning the tubes. The amount of air removed by the air pump while at work depends on its volumetric capacity and efficiency. As regards the vacuum augmenter, this can be made more effi-

cient as an air remover than an ordinary air pump, but the amount of power required is at present, I believe, an open question, and not to be recommended, except a high vacuum is required, as in turbine work.

W. Vincent Treeby.

Stratford, England.

Wrenches

On page 15 of the January 5 number, Mr. Collins gave some sensible advice in regard to the use of wrenches. With an extended experience in charge of men and tools, I have had all the trouble enumerated by the author in the misuse of wrenches.

There is one statement, however, that is not absolutely correct, and that is where he says a pipe wrench should always be used close to the fitting the pipe is being screwed into. On extra-heavy pipe and generally on butt-welded iron pipe this will do, but on standard pipe the wrench should be at least one and a half times the diameter of the pipe from the fitting; if it is a close nipple, a nipple driver should be used. The reason is that the wrench distorts the pipe and the oblong frets bind in the fitting. This is especially so where it is necessary to remove a light nipple from a fitting, when it will be found that it will start more easily if the wrench is a proper distance away. There is a strap wrench made that will not crush even the lightest brass pipe, or injure the surface of studs or pipe, that Mr. Collins did not get into his very complete list of wrenches.

Peter H. Bullock.

Concorn Junction, Mass.

Turning a Worn Turbine Shaft

While putting a new guide bearing in one of our 5000-kilowatt Curtis turbines we found the shaft worn badly on one side. We proceeded to put the guide bearing in, but before putting up the dies, we took measurements in order to make a turning tool with which to turn the shaft down. The accompanying sketches show how we did the job.

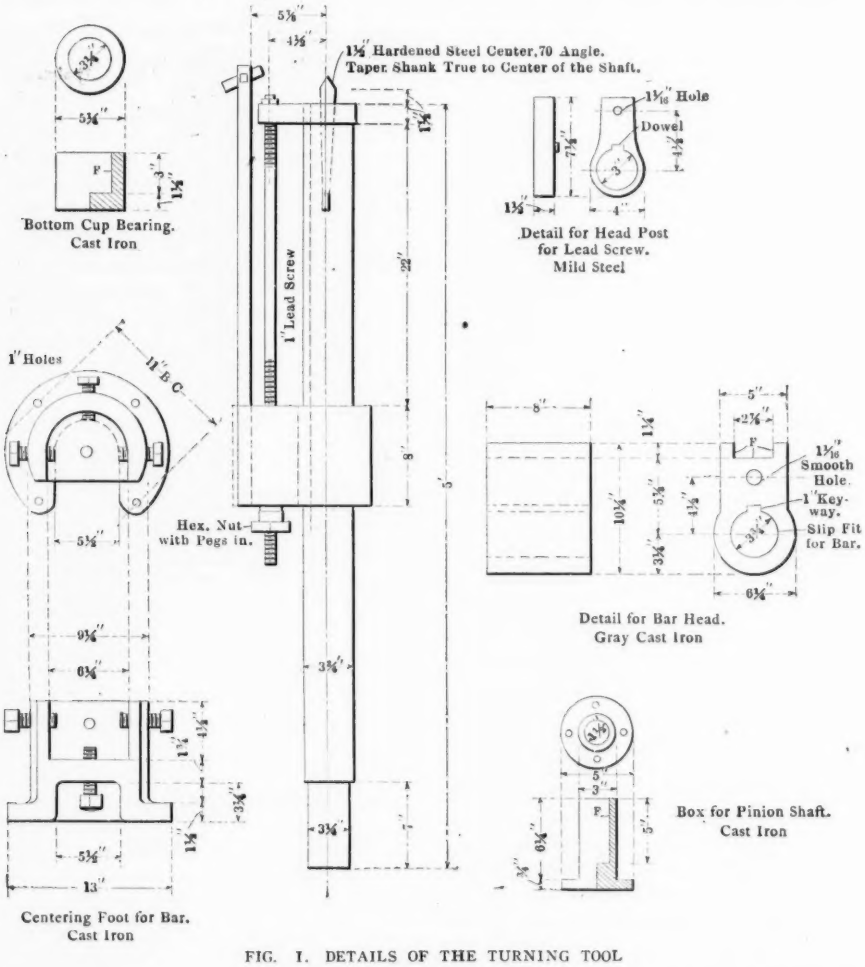


FIG. 1. DETAILS OF THE TURNING TOOL

In Fig. 1 are shown the details of the turning tool. Fig. 2 shows the machine in operation. I would suggest, however, to anyone desirous of using this machine, to substitute a worm gear for the gearing shown, use a small motor for a drive and mount it where the crank is shown.

As we were pushed for time we took the crank from a drill press and turned the turning tool by hand. It took only three days to remove 0.09 inch from the diameter of the shaft, the shaft being 11 inches in diameter and the cut 17 inches long.

In order to center the bar we used the center in the end of the turbine shaft. About 16 inches from this end we found a place where there was an oilway in the box, hence the shaft was not worn at this point. We could not get a very smooth finish with the long toolholder we had, but we got the finishing touches on by placing a piece of ⅜x1½-inch band iron in the place of the toolholder, with an emery brick fastened to the end. By putting a set screw in the lower end of this strap-iron, we could work that end away from the head and thus increase the tension on the brick. We used water on the brick.

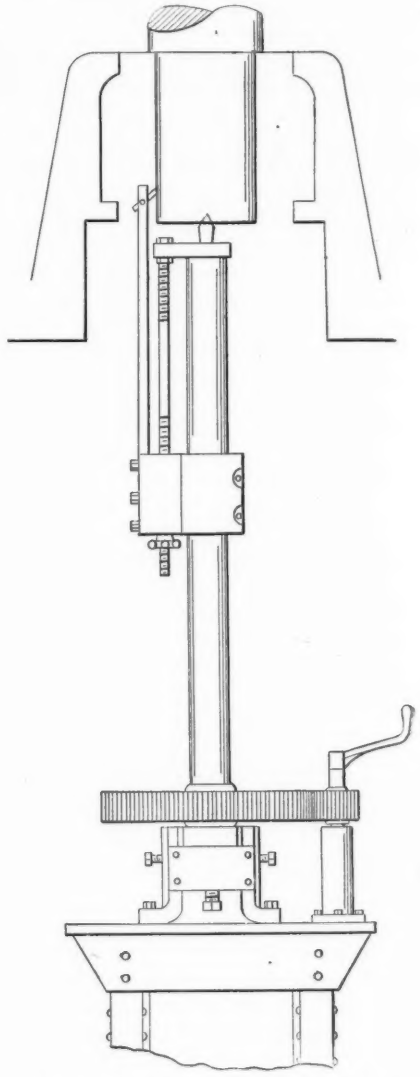


FIG. 2. HOW THE MACHINE IS OPERATED

As the space betwen the shaft and bearing case was too close to get an ordinary incandescent lamp in we mounted one of the oil-switch pilot lamps on a broomstick and used it for a lamp.

Edward H. Lane.

Kansas City, Mo.

Development of the Surface Condenser

Descriptions of the Various Types of Surface Condenser, Beginning with Watt's and Including the Most Modern Apparatus on the Market

BY WARREN O. ROGERS

To James Watt belongs the distinction of designing the first surface condenser, although it is true that Savary condensed steam in the cylinder of his engine, if engine it may be called, by pouring cold water over it to produce a more rapid vacuum.

In Newcomen's engine, which was the first reciprocating engine put to practical use, the steam was condensed from the bottom end of the cylinder. The piston was kept tight by a small amount of water on its upper surface. When the piston reached its highest point of travel, the injection valve *A* was opened, and water admitted to the cylinder, as shown in Fig. 1. This supply of water condensed the steam, the air escaping through the vent *B*, while the condensed steam and injection water passed out through the pipe *C* to the hotwell *D*. From this it is evident that the first condenser was of the jet type, which was also the type first designed by Watt, although it must not be assumed that the idea was the growth of a moment. When Watt observed the wastefulness of Newcomen's method of condensing steam he tried various means of remedying the defect by experimenting with different materials for cylinder construction, in order to find a substance that would take in and give out heat slowly. It was only after an examination of the properties of steam that he concluded that two conditions were essential to the economical use of steam in a condensing steam engine, one condition being that the temperature of the condensed steam should be as low as 100 degrees Fahrenheit, or lower, in order to maintain a good vacuum; the other, that the cylinder should be as hot as the steam entering it.

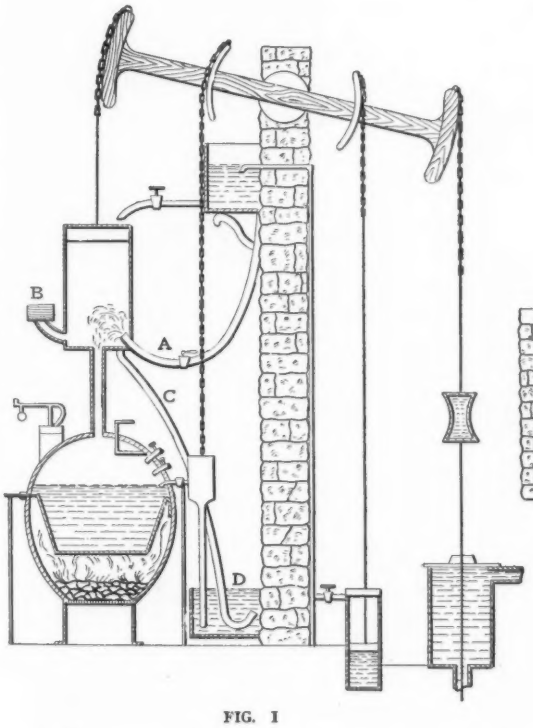


FIG. 1

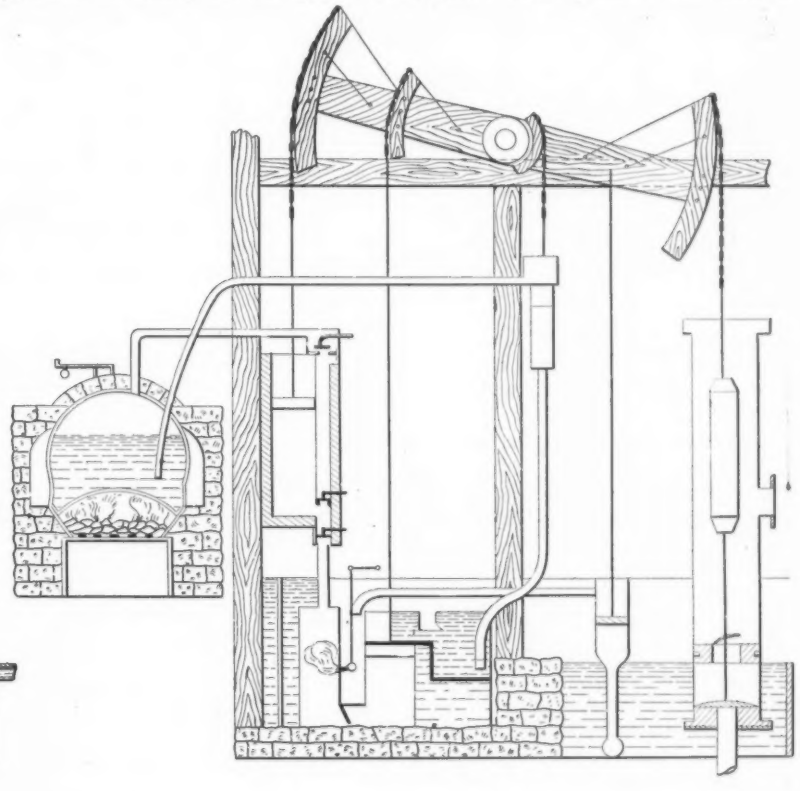


FIG. 2

In 1765 Watt conceived the notion that by condensing the steam in a separate vessel these two conditions could be maintained and the idea was put into practice. Fig. 3 shows the design of this condenser. It consisted of a vessel separate from the engine, into which the exhaust steam from the engine was allowed to flow through the opening at the top. The steam was condensed by cold water surrounding the outside and also by a jet of water on the inside. An air pump removed the condensed water, as well as the air in the condensing chamber. The inlet between the condenser and the air pump was fitted with a swing foot valve, and as the plunger was fitted with valves the water was forced up through them to the top of the plunger, on its downward stroke, and expelled through the discharge pipe on its upward stroke. This condenser embodies the principles of both the jet and surface condenser in a crude form. This invention was not patented until four years later, and it was three years more before steam pressure and vacuum were applied to both sides of the piston. Even with the vacuum acting on but one side of the piston the gain over the old method of condensing the steam in the cylinder is said to have been 32 per cent.

The specifications of the patent granted to James Watt, January 5, 1769, read in part as follows:

"In those engines that are to be worked wholly or partially by condensed steam, the steam is to be condensed in vessels distinct from the cylinder, though occasionally communicating with them. These vessels I call condensers, and whilst the engines are working they ought to be kept

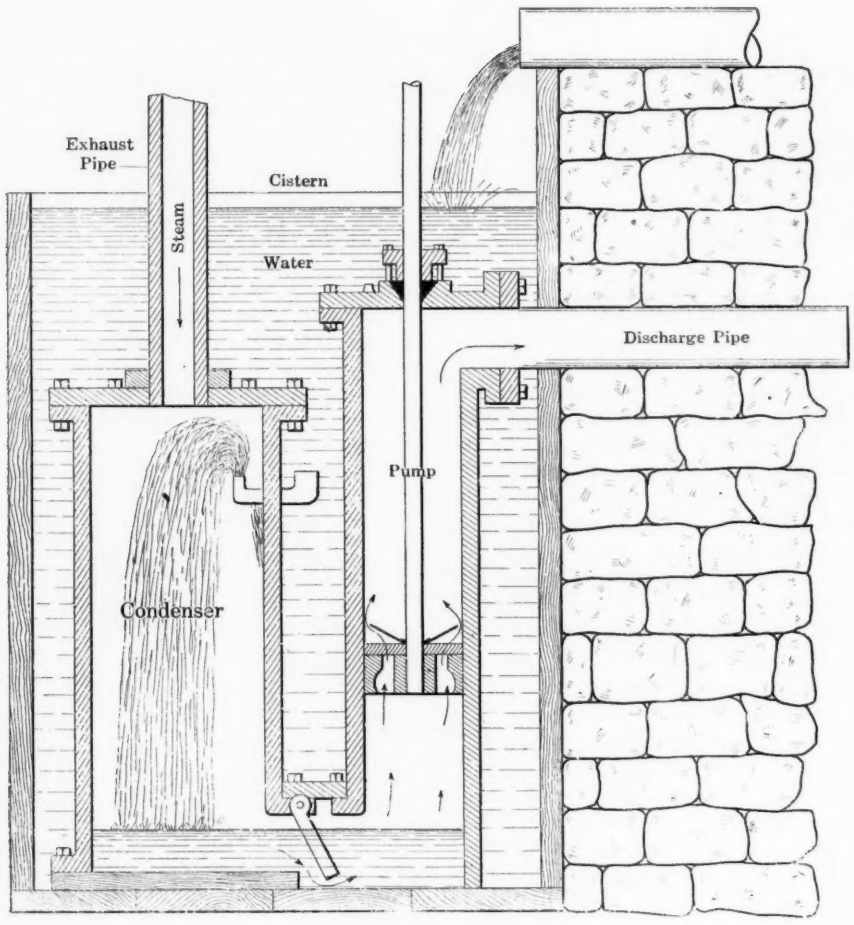


FIG. 3

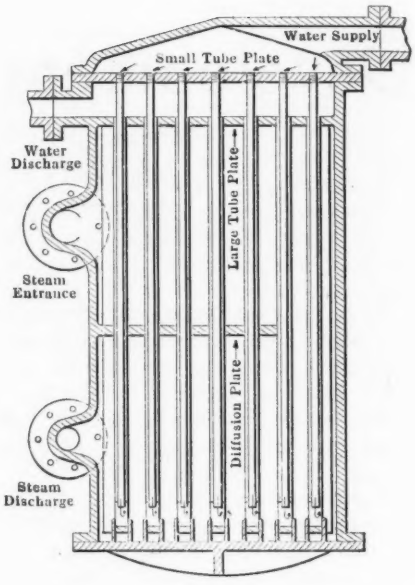


FIG. 6

as cool as the air in the neighborhood by the application of water or other cold bodies."

There were no drawings attached to the specification papers, but from fragments of Watt's experimental apparatus it is evident that the design shown in Figs. 2 and 3 is approximately the arrangement of the first separate condenser, from which grew the surface condenser, although the jet type was employed by Watt in connection with his subsequent engines, and became almost universally used during the years preceding 1831. Fig. 2 shows Watt's engine and condenser of 1769.

In 1831 Samuel Hall invented a commercial surface condenser. In the specifications of Hall's patent the following may be found:

The condenser "consists of an improved mode of using a system of metallic surfaces, which may be composed of vessels, channels, passages, or pipes, of any convenient form and arrangement for condensing the steam and cooling the water resulting therefrom on its passage from the condenser to the air pump."

Two years later Hall obtained a second patent in which the circulation of the condensing water is described as passing through a cistern containing the tubes, the cold water entering the cistern at the top at the end of the cistern nearest to the air pump, and escaping at the bottom of the other end next to the working cylinder. In the Hall condenser the *steam* flowed *through* the tubes, the cooling water flowing about them on the outside. With this exception this condenser of seventy-six years ago was practically the same, as far as construction goes, as many of the surface condensers of today.

A type of this condenser is shown in Fig. 4, in which the general arrangement of the condenser and air pump is illustrated. It is seen that the steam passes downward through the tubes to the air-pump suction. The circulating water was circulated upward by a centrifugal pump. Strange as it may seem, the design of surface condensers remained almost the same as it was in 1831, up to within a few years. The most important change made

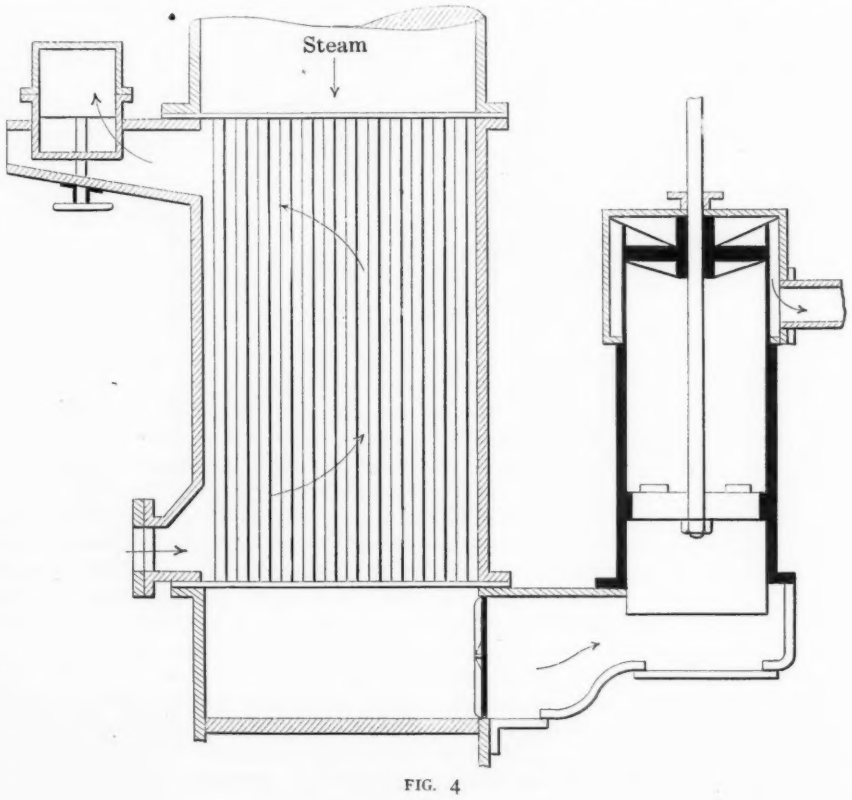


FIG. 4

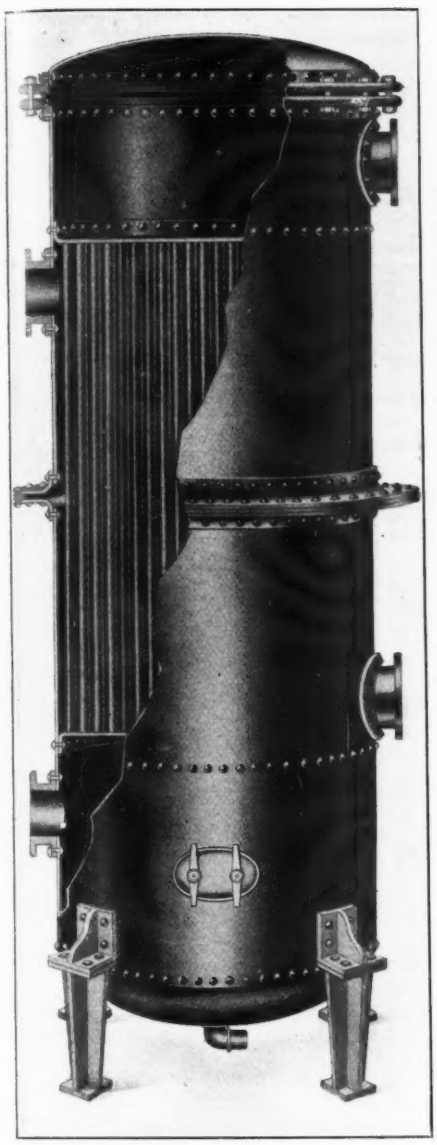


FIG. 13

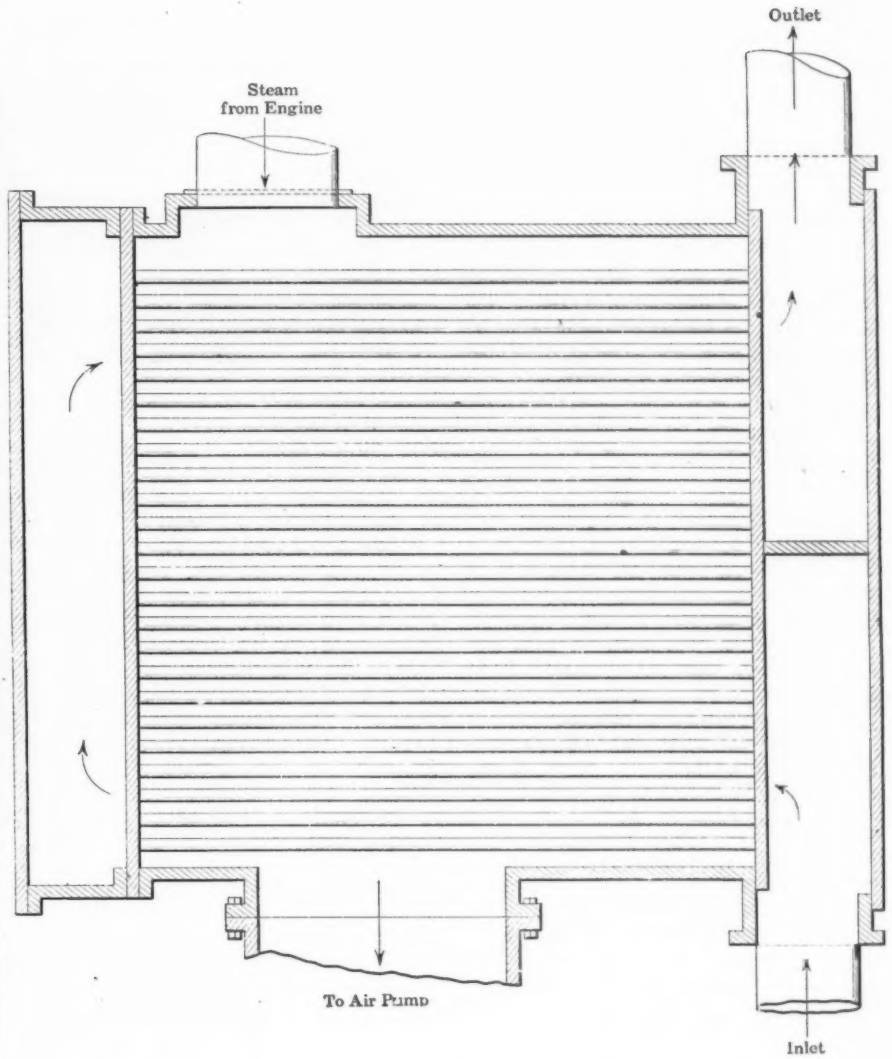


FIG. 5

has been that of circulating the cooling water through the condenser tubes instead of the steam; this change is preferable, and is now invariably adopted. Probably J. F. Spencer took as active a part as anyone in introducing this latter method of circulating the cooling water.

In Fig. 5 is shown a condenser designed and built for commercial use more than thirty years ago. It will be seen that the condensing surfaces consist of two nests of tubes with a baffle plate central in the inlet-water chamber. The cooling water coming in at the bottom and passing to the left through the bottom bank of tubes enters the chamber at that end and, reversing its direction of flow, passes through the upper bank of tubes to the outlet. The steam from the engine cylinder enters at the top inlet and passing down over and surrounding the tubes, is condensed, the water of condensation passing to the air pump through the bottom outlet.

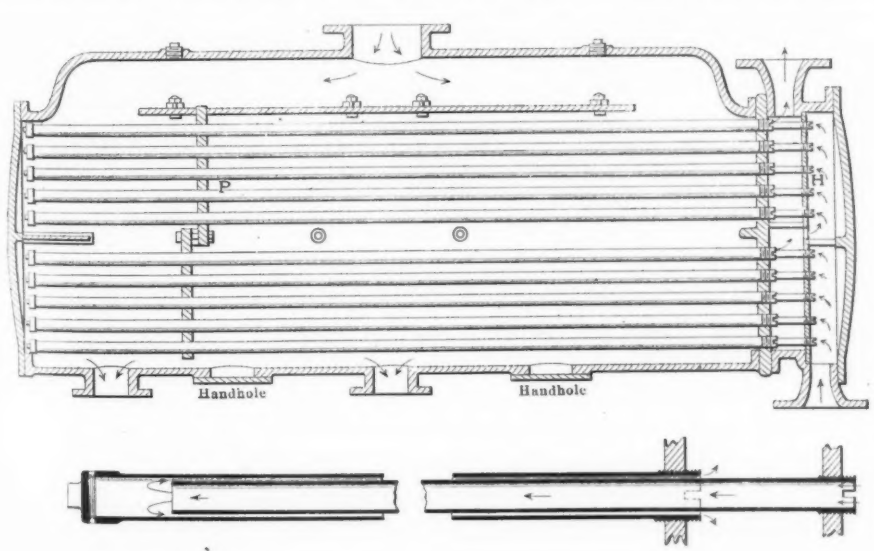


FIG. 7

The first double-tube surface condenser was designed by an American named Miller, in 1869. In this design, Fig. 6, small tubes were placed inside of large ones. The condensing water entered the water chamber through the bottom inlet, from whence it passed through the small inner tubes, returned through the large outer tubes, and then discharged into the air pump. This is practically what is found in the modern type of surface condenser, with the exception that they are generally made to be placed in a horizontal position, the steam entering at the

top and the condensed steam discharging at the bottom.

In Fig. 7 is shown the modern type of double-tube condenser. A comparison with Fig. 6 shows but a slight difference in construction. No ferrules, washers, or packing of any kind are used, the tubes screwing firmly into the tube heads at one end, as shown, thus taking care of the expansion. The arrows designate the path of the cooling water, also that of the steam and products of condensation.

Fig. 8 shows a type of single-tube condenser familiar to all. The design allows of a good distribution of steam, and each tube is supposed to do its share of work. The arrangement of the air and circulating pumps is also shown. In the condensers shown in Figs. 7 and 8 the weight of the condenser rests on the air and circulating pumps. While this does not interfere with the attendant getting at the valves of each, it does necessitate an extra amount of work when it becomes necessary to remove the air or circulating pumps. To obviate this, some builders of surface condensers manufacture a design which is supported independently upon four or more supporting columns.

In Fig. 9 such a type is shown. It is manufactured by the Epping-Carpenter Company. By breaking the connection between the condenser shell and the pipe connection to the pumps, either the condenser or duplex pump may be removed without disturbing the other. The interior construction of the condenser is shown in Fig. 10. The tubes are held in place by means of screwed glands on one end and so made that expansion and contraction are taken care of. Fig. 11 shows the construction of the tube packing and glands. The arrows indicate the path of the circulating water; in this case two passes of the water are provided for, but as many as desired may be provided.

The application of the surface condenser is varied. That they may be attached to the individual auxiliary is

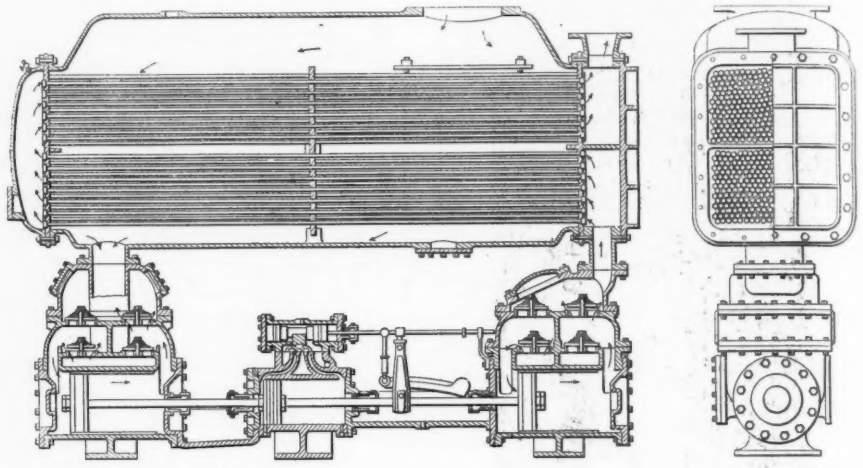


FIG. 8

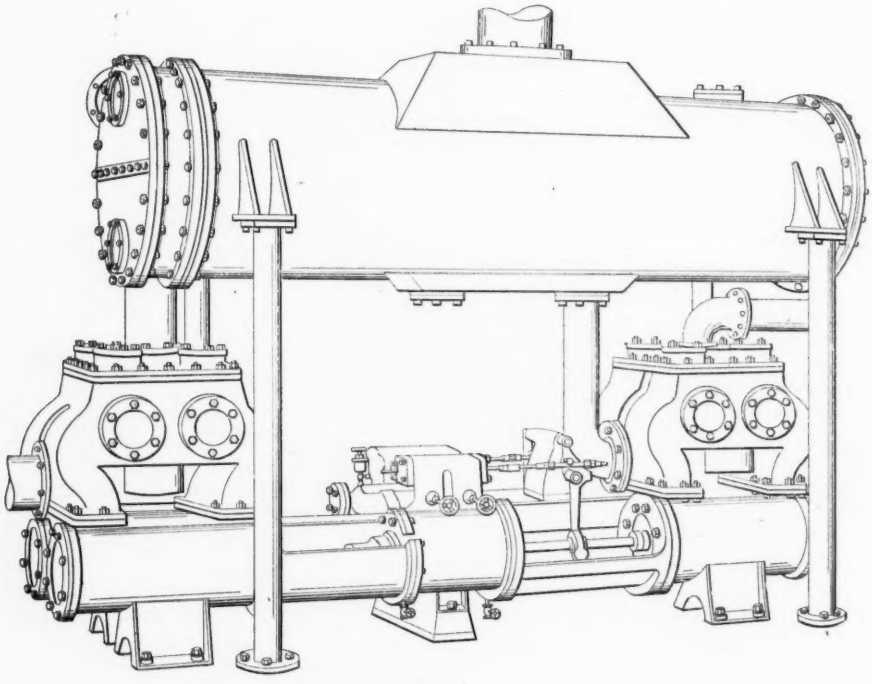


FIG. 9

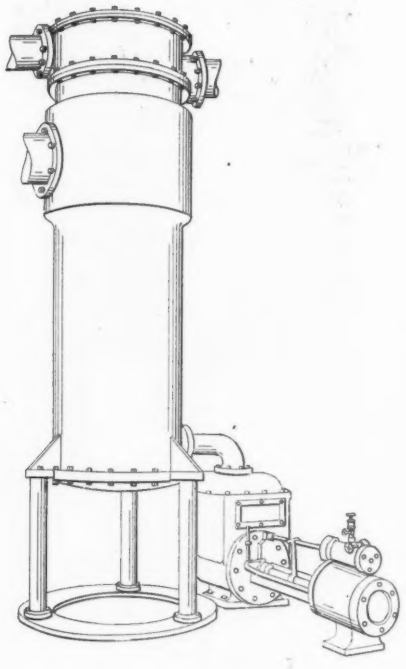


FIG. 14

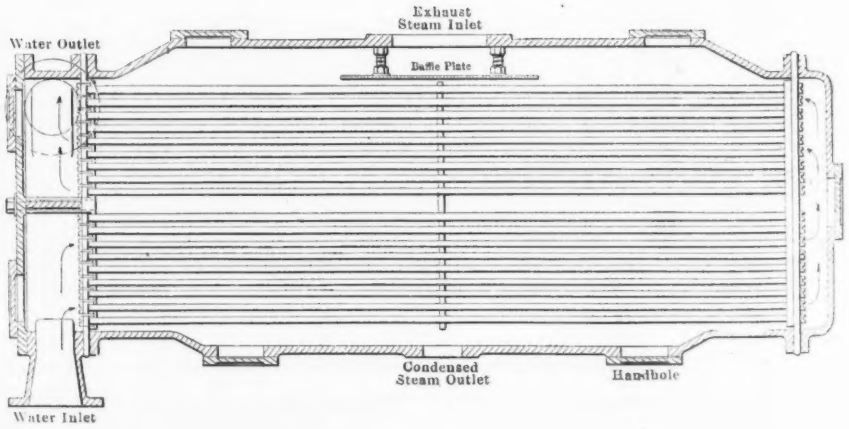


FIG. 10

shown in Fig. 12. This represents one type of surface condenser manufactured by the Union Steam Pump Company. It is a most convenient arrangement under certain conditions. An independent air pump is used to remove the water of condensation and maintain a vacuum. The water handled by the pump is forced through the condenser tubes and, as the amount of water passing through them is many times greater than that necessary to condense the steam, it is evident that the condenser is very efficient. The water passages are made large, and the resistance to the passage of the water is slight.

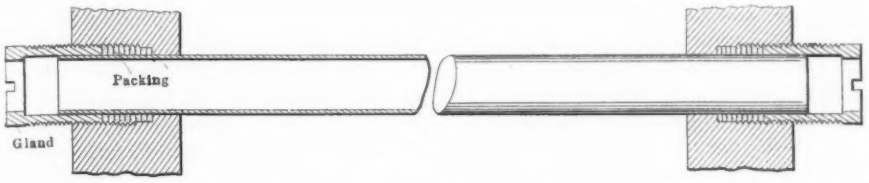


FIG. 11

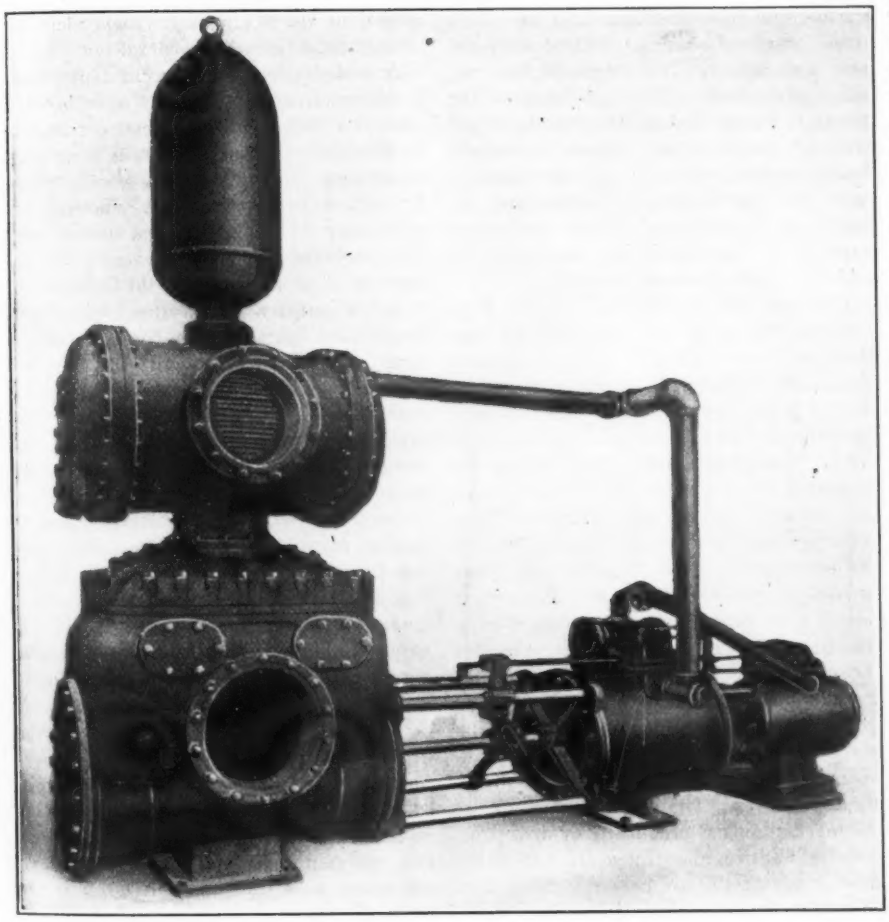


FIG. 12

A condenser of entirely different construction, as regards expansion and contraction, is shown in Fig. 13. The tubes of this condenser, which is manufactured by William Baragwanath & Son, are expanded solidly into the tube sheets, the expansion being provided for by the expansion joint in the shell, as shown. This condenser is of the vertical type, although it is also made in the horizontal form. In the vertical type the top head is removable and, as the lower end contains a chamber which is fitted with a manhole, the tubes are accessible at both ends for cleaning. The upright position of the tubes, which are made with a large area, makes a natural circulation. In case floor area is restricted, this type of condenser has its special advantages.

In Fig. 14 is shown another type of vertical surface condenser. It is manufactured by the C. H. Wheeler Manufacturing Company. The cooling water enters at the top and, passing down through one bank of tubes to the bottom of the condenser, reverses its direction of travel and passes up through the second bank of tubes and out on the opposite side of the shell. The exhaust steam enters the large opening at the top of the shell and the water of condensation is removed by the air pump shown at the base of the condenser.

Cooling Towers

By H. F. Blake

Cooling towers and cooling-tower practice represent a comparatively recent development in engineering progress. While their adoption has been rapid, the question of design and efficiency is in a somewhat chaotic state. Comparatively little is known by the average engineer in regard to the relative efficiencies of the different types and their respective advantages for special installations.

Cooling towers today serve simply one purpose, in a variety of applications: To cool water in industrial operations where large quantities of water are required for any purpose whatever and the necessity of the water being cool is a prime requisite. Thus, in all steam-power plants of any type whatever, cooling towers are used in conjunction with the condenser for furnishing a continuous supply of cold water to it. In all refrigerating installations and ice-manufacturing plants they serve the same purpose and supply cold water for the operation of the ammonia condenser, in which a large amount of cold water is used. In any of these installations the cooling tower is necessary wherever the water supply is removed, limited in amount or too impure for use. They take the water from the steam condensers, after it has become hot through the condensation of steam, and cool it mechanically so that it can be used over again for the same purpose. They serve essentially the same purpose in any plant where the water is used to absorb heat and hence loses its ability to do so when it becomes hot.

Classification of Cooling Towers

Cooling towers may be divided into two classes, the inclosed and open types. Both of these operate by the use of air, which is obliged to absorb water vapor under certain conditions to produce cooling. Water vapor exists in the air in amounts dependent simply upon the temperature and the approximate closeness of a suitable water supply for renewals. It tends to occupy ordinary space independent of the presence of the air. It exerts a definite pressure which approaches maximum for a given temperature, when in immediate contact with a water surface, and this condition of the vapor is known as saturation.

This phenomenon of water evaporation, and its condensation with fall in temperature in space, is independent of the presence of the air. The latter serves merely the purpose of transferring large quantities of water vapor

readily by mechanical means, since the pressure of the latter under ordinary conditions is quite small. The ordinary water vapor in the air is in an unsaturated condition, due in a great measure to the fact that the air or water vapor has become heated some time after its contact with a water surface. When brought in contact with this, however, it absorbs additional water in the form of vapor until it becomes saturated. Air in reality generally possesses the remarkable property of absorbing large quantities of water vapor from a water surface with which it is brought in contact. It can only do this, however, when the water vapor present is in an unsaturated condition.

Very seldom in actual practice, except during periods of rain or great humidity, does the air or the water vapor approach the saturation point. Under these latter conditions, however, the air does not absorb water vapor, and therefore possesses very little cooling effect on the water. This cooling effect under ordinary circumstances is very large, since every pound of water evaporated by this means is accompanied by the absorption of heat from the remaining water, equivalent to the latent heat of vaporization of the water changed into the vapor. Cooling towers are quite variable in their action as dependent upon the condition of the atmosphere in regard to humidity, since the actual loss of heat by conduction from the water to the air is quite small under all circumstances.

This variability of cooling towers with atmospheric conditions has led to the development of the two types. The amount of cooling produced depends primarily upon the condition with respect to humidity of the air and, secondly, upon its temperature. The capacity of the tower depends upon these factors and upon the amount of air brought in contact with the water per unit of time. This latter feature is the main determining factor in the development of the two types. These are known respectively as the closed and open types of tower.

The Open-type Tower

The open type consists of an openwork iron structure, with a standpipe for the conveyance of the supply water to the top, and possesses a spraying device at this point and various devices installed throughout the tower for the separation of the water into small particles with large surfaces for evaporation and its retardation throughout the descent. This mechanism furnishes a very large water surface for contact with the air, and assures complete saturation of the air in the tower.

By great retardation of the descending water very large quantities of air can be brought in contact with a given water surface, therefore the amount of water abstracted from it in the form of vapor can be made comparatively large and the cooling produced by this means considerable. Such a tower is open at the sides and depends for air circulation upon the natural air circulation in the atmosphere. Its efficiency varies with the velocity of the wind, its humidity and temperature, and also upon the design of the tower for separation and retardation. Various interesting problems in constructive details have arisen, and the deterioration factor in this type is quite large, since the destructive effect of air and water under these conditions is most pronounced.

The Closed Type

The closed type of tower is practically identical with the open type in construction, with one important modification. The walls of the tower are inclosed and air is supplied at the bottom and forced upward throughout the tower by means of a fan. The air supply under these circumstances can be varied by mechanical means and the resulting cooling effect made practically independent of temperature and humidity variations of the outside atmosphere. The operation of the tower is further independent of the existence of winds for its efficient operation. Such a tower, however, costs considerably more in regard to installation and its operating factor is much greater, since expense of operating the fan must be added to that of water circulation.

However, as an engineering unit, it is considerably more reliable and, as has been said, can be made in its operation absolutely independent of external conditions. It further eliminates another serious difficulty which has arisen in the open type: When high winds exist during the operation of the latter, the water cannot be restrained within the confines of the cooling tower, and a fine spray covers all the surrounding objects. This has often proved a considerable annoyance from lawsuits in regard to the nuisance produced by this means. Farther, the deteriorating effect on the other units in the installation cannot be overlooked.

These two types of tower represent practically the sole developments in this field. They exist in a wide variety of designs, however. The chief open types on the market consist practically of drip pans installed at regular intervals, allowing free access of the air between them, and possessing holes in these at regular intervals for the equal distribution of the water. Shavings, boards, mineral wool, tile and even slate have been used with greater or less success in this type and in the closed type as well. The question is largely one of expense of installation and the consideration of the deterioration factor. Almost any device for satisfactory distribution and separation of the water with adequate retardation is thoroughly sufficient for the purpose.

Where Each Type is Used

The result in the development of these various types of tower is that there has been a distinct specialization of the various designs. Thus, in installations where reliability is a matter of prime importance and cost of installation a matter of minor significance, the closed type is invariably installed. The majority of large power plants use the closed type. In some developments these towers are used as an integral part of some other device, such as a condenser, and are operated along with it.

On the other hand, in plants where the cost was a matter of the greatest importance, and the possible isolation of the tower a simple problem, the open type has been developed. In the majority of small refrigerating and ice-manufacturing plants where the question of cost is a matter of prime consideration, the open type is almost invariably installed. Similar conditions hold in regard to the small steam unit and this subdivision of the two types and their developments as dependent on related conditions is a general one.

A wide variety of different types from a constructive point of view have been in existence, but a more and more complete standard of constructive details is steadily developing. Much more is known today in regard to capacity and efficiency of such towers. Cooling towers under average conditions are more thoroughly known, and the size and cost of the installation depends primarily upon the locality and amount of water to be cooled and the range of temperature required. Very seldom in summer can the water be cooled much below 75 degrees Fahrenheit. The higher the temperature of the initial water, however, the more efficient is the tower in its operation.

Condenser water from steam condensers is furnished at a temperature ranging from 110 to 165 degrees Fahrenheit down to 80 degrees Fahrenheit, and their operation under these circumstances is very efficient. Refrigerating plants have a range of temperature depending simply upon the pressure maintained in the condenser and seldom rises above 120 degrees Fahrenheit for initial temperature in the cooling tower. The evaporation of the water in the cooling tower must, of course, be re-supplied, and this represents a certain loss. In steam-condenser work, if the condenser is of the jet type, the water is more than re-supplied from the condensed steam and a constant overflow must exist. In refrigerating plants the loss of the water is from 5 to 15 per cent. for each circulation, and this loss must be re-supplied.

The efficiency of a cooling tower, of course, depends primarily upon the cost and availability and character of the water supply. It must not be pumped too great a distance, or too great a hight. Practically every individual plant presents special conditions for consideration in regard to its availability, and the efficiency of the type is practically dependent upon these special conditions.

Some Useful Lessons of Limewater

Hard Water and Boiler Scale; How to Make Carbonic Acid Gas Water; the Action of Limewater Upon Litmus Paper; Acids, Alkalies

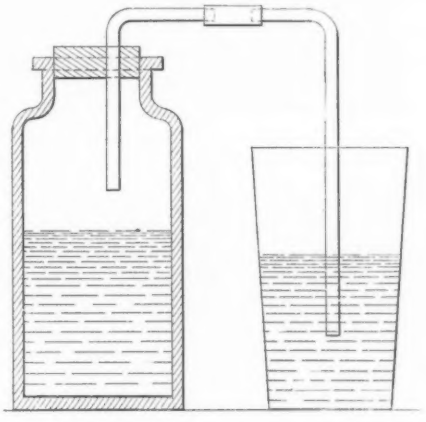
BY CHARLES S. PALMER

In the first shift, Mr. Furnaceman, you got the idea that lime will dissolve somewhat in water; that the lime can be thrown out of solution as plain carbonate (which is not soluble in water) by the carbonic acid of the breath, and by the same thing from the burning of common coal; it was also noted that by adding more of this carbonic acid from the breath, or from the gases of the burning coal, to the water with the insoluble plain carbonate of lime, you got the fairly soluble extra or bicarbonate of lime. You saw that this solution of somewhat soluble extra or bicarbonate of lime, after filtering, is the same thing as artificial temporary-hardness water; for, on filtering it to get it clear, and then on heating it, the extra carbonic-acid gas goes off, and down comes again the insoluble plain carbonate. You saw quite a little of this insoluble plain carbonate, both as a sediment in the bottom of the glass, and also as a scum or thin flaky crust floating on the surface of the water. If you shake this and let it settle, you will get enough to show that this plain carbonate of lime could make trouble if it were in any great quantity. This plain insoluble carbonate of lime is what makes the soft scale of temporary-hardness water; in contrast to the hard sulphate-of-lime scale, which makes the scale of permanent-hardness water, which will be studied later. There are also compounds of the metal, magnesium, in many hard waters, and they will be taken up later on, also, after the lime compounds are disposed of.

Now, the thing to get clearly in mind is this: That even a *little* scale is a bad thing to have on the boiler tubes. It may not take a layer as thick as your hand to make both danger and extra cost in firing the boiler. And it is costly, not only for the management that pays for the coal, but also for *you*, the man who must handle it all.

Of course, we may shrug our shoulders when the books try to tell us just how much heat is lost by scale of such-and-such thickness; for if one is not rushing the fire, and if there is more than enough heating surface in the boiler and tubes to absorb the heat of the furnace, the scale, especially if it is not very thick, may not do much damage. But, if your boiler has none too much heating surface, and if you are forcing the fire, that may be an entirely different matter, as you may know from actual experience. So we will not tie ourselves down to any special figures on the heat loss from scale of any particular thickness, but we must all agree that any scale is liable to cause both waste of coal and waste of the fireman's own good strength, not to mention some danger. That is why we are trying to get together on this eternal riddle of hard water.

To go back to the first solution of filtered limewater, the stuff that tastes slightly bitter-sweet, that throws down plain insoluble carbonate of lime, both from the breath and from the gases from the burning coal: This sediment was fairly soluble in extra carbonic acid, making the double or bicarbonate, which is somewhat soluble, and this is thrown down by heating, just as the temporary-hardness water is cleared up by your heater; that is, if it works all right. But



FOR MAKING CARBONIC-ACID-GAS WATER

it takes time to throw out the lime from the hard water in the heater; and it takes time for it to settle, and that will set you to thinking of some way to handle the heater, so that it will always do its work in softening the water, as it may not always do.

More About Carbonic-acid Gas

We have found out, in the foregoing, four things about the lime: the solubility, the insolubility, the resolubility and the reinsolubility. But you want to know more about this carbonic-acid gas which picks up the lime from the insoluble limestone bed and carries the extra, or double, or bicarbonate of lime down to your boiler room. You can see that if this carbonic-acid gas should get into the water which seeps through the limestone bed, it will naturally take some of the plain carbonate from the bed and carry it along. For there is some carbonic-acid gas in the air; and so, of course, this gets into all natural water, more or less.

If you pour some of the filtered solution of limewater out into any open dish, as a glass tumbler, in a few minutes you will see a thin scum form over the solution. This scum will form a thin skin over the surface of the limewater, and this white skin is the same plain insoluble carbonate of lime that you got by putting the gas from the burning coal, and from breathing through limewater. As you look at your bottle of filtered limewater, you will note that with all your cleaning, the cork and neck of the bottle are smeared with the same white, plain carbonate of lime; indeed, some of it has got into the bottle of filtered limewater, especially if you have allowed the water to get low in the bottle so that there is quite a little air in the bottle above the filtered solution. This means that you will have to filter the limewater again from time to time, for the air about us is always at hand and it is always getting in its work on the filtered limewater. There is not much carbonic-acid gas in the air, only about one part in thirty-five hundred, but this is quite enough to show with so sensitive a chemical as limewater, and with the insoluble carbonate so ready to form.

You are probably quite well acquainted with this carbonic-acid gas; you may know it very well as "soda water," or as the "fizz" which is used to mix with other things. It is kept in that strong "siphon" bottle, and the thick walls of the siphon bottle, the readiness with which it squirts out as one presses the finger valve on top, together with the strong foaming in the drinking glass, all show that the carbonic-acid gas in the siphon bottle is under strong pressure; indeed, the water in the siphon bottle is quite a strong solution of this carbonic-acid gas.

If you should take some of this water from the siphon bottle and pour it into some limewater (very little of it, for this is a strong solution of the carbonic-acid gas), you would get the same white insoluble plain carbonate of lime. And if you should squirt into this some more, quite a little more, of the water from the siphon bottle, you would make the same fairly soluble, extra, or double, or bicarbonate of lime as before with the slow and tedious blowing of your breath, or by sucking the gases from the glowing

coal. In this way, you would make the temporary-hardness water; and, after filtering it, because the bicarbonate of lime is not quite soluble enough in water to dissolve entirely, you would have a clear solution, which would throw down the plain carbonate, as before, by heating.

How to Make Carbonic-acid-gas Water

It may not be handy to get a siphon bottle of carbonic-acid-gas water, but all the same you want some of it. So you will make it yourself. Just rig up an apparatus consisting of a bottle, a tumbler and tubes, as shown in the accompanying sketch. Take a wide-mouthed bottle, say a common horse-radish bottle, and a common tumbler. The bottle is closed with a flat cork, pierced by one hole for the tube to carry the carbonic-acid gas to the tumbler. The tube is made of two pieces of glass tubing, joined with a bit of rubber tubing (which you can get with the outfit mentioned in the first lesson). In the bottle are placed some lumps of common white marble, which is nothing more than plain carbonate of lime (or calcium). Pour over the marble about two or three inches of water, and then about one-fifth as much hydrochloric (muriatic) acid. If you do not have the acid, you may use vinegar; but in that case, do not add any water, and have the vinegar warm. Hydrochloric acid is more active than vinegar and cuts the marble quicker than the vinegar does. You will see quite a foaming; clap on the flat cork and lead the carbonic-acid gas which comes off through the tube, passing through the flat cork, into the tumbler, which contains some of the original filtered limewater. As the carbonic-acid gas comes over and passes through the limewater, you will get the same white insoluble plain carbonate of lime (or calcium), and if you keep the current of gas going, pretty soon you will see the same change in the precipitated limewater which you got from blowing your breath through limewater, and from sucking the gas from glowing coal through limewater. Thus you see that you can get this carbonic-acid gas from the breath, or from burning coal, or from limestone. The carbonic-acid gas is locked up, "fixed" the old chemists used to say, in the limestone, which is carbonate of lime; and when you add some strong acid to limestone, this acid displaces the carbonic acid, forces it out and, as carbonic acid happens to be a gas, you can grasp the explanation of the action of this apparatus.

If you use vinegar, take about a cupful, for vinegar is only a diluted, or thin, solution of acetic acid in water. You might use nitric acid, also, but that usually costs more than muriatic (or hydrochloric) acid; but you will not use sulphuric acid, because this acid in acting on limestone makes sulphate of lime (or calcium), and this is so insoluble that it coats over each lump of limestone and shuts off the action. But to go back to the experiment:

You were driving the carbonic-acid gas over into the limewater; you had got the same plain insoluble white carbonate-of-lime precipitate (a "precipitate" is anything thrown out of solution when two clear liquids are mixed, and one liquid is said to "precipitate" the other; also, the thing thrown out of solution is said to be "precipitated") as with the breath and limewater, or with the gas from glowing coal and limewater. And, as in those cases, with more carbonic-acid gas led into the precipitated insoluble lime carbonate, you get the same extra, or double, or bicarbonate of lime. Keep the liquid in the tumbler shaken up, as the gas bubbles through, so the carbonic-acid gas can act on the insoluble carbonate of lime in changing it into the extra carbonate of lime. When it shows the change of beginning to be more soluble, as though you could almost see through it, take the tumbler and filter the contents, and you will have the same solution of extra, or double, or bicarbonate of lime (or calcium) that you had before; in fact, some of the temporary-hardness water.

If this is warmed, down comes the same insoluble plain carbonate which makes the scale. If you don't happen to have any pieces of marble, you may take instead a handful of common cooking soda from the kitchen at home; only in this case, you will have to add it a little at a time, because the acid will act on it almost as soon as it is thrown into the wide-mouthed bottle, which has strong acid in the water. If you keep right at these homemade experiments you will begin to see how easy it is to follow one thing up after another, and these tests that you are making are just the sort of thing that the thinking man has to use and study everywhere.

The Action of Limewater on Litmus Paper

But there is one fact about limewater that you ought to know by this time. That is its action on litmus. You have a sheet of this litmus paper or a little package of it cut into strips, with your outfit. If it came in one sheet, cut some of it into little strips about a ¼ of an inch wide and 2 or 3 inches long, and put them in any clean, wide-mouthed bottle, which you will keep corked and handy for use.

This litmus paper, so say the books, and they are useful occasionally, is turned red by acids and blue by alkalies. As Long Jack said to Harvey Cheyne (in Mr. Kipling's "Captains Courageous") about shiptackle, this is one of the things that "ivry man must know, blind, dhrunk, or asleep." This must be learned once and for all. Litmus, *acids red, alkalies blue.*

All right, but what about limewater? Just try it. If you have red litmus to start with, it turns *blue* in the limewater, and if you have *blue* litmus paper, it *stays blue* in the limewater. So, then, our limewater is an alkali. This is a big piece of chemistry, and it is a leading fact by which to find out thousands of other facts which are worth dollars to the man who will have the sense to use them. *Limewater is an alkali!*

Acids and Alkalies

Let us take a little excursion among the common things over on the boiler-room shelf, or in that interesting old pantry, and you will find it just bursting with information which it is a thousand times better for you to find out in this practical way than merely to read about in the books. There are salt, pepper, spices, sugar, soap, soda, vinegar, ammonia water, and perhaps a lemon, a sour orange, or an apple. Now some of these are active chemicals, and some of them, while having plenty of *taste,* are indifferent to litmus or useless for our purpose. But you will soon find that the soap, the soda, and the ammonia will each turn the litmus paper *blue* like the limewater, so they are all alkalies, or have some alkali in them, while the vinegar, the sour lemon and orange, and even the apple, will all turn the litmus *red,* and hence contain acids.

This division between *acids* and *alkalies* is as old as Mother Nature, though chemists did not begin to get onto this important fact until two or three centuries ago; but it is just as Long Jack said about his shiptackle, it must be riveted into the mind of attention and into the finger of testing. You cannot afford ever to forget it, or to think that it does not matter particularly whether or not you make the test, even if you think you know about what it is without testing. Make the test; do it; and then you can explain why it was that something happened that you were not expecting, as it always does in the long run. That waste water over there in the corner may be chewing out your pipes; litmus may tell something; but that story comes later.

But you must stop awhile with the soap, the soda, the ammonia, and the limewater on the one hand, and with the vinegar, the sour fruits and the like, on the other. As you go on you will find that there are several other acids: sulphuric, nitric and hydrochloric (or muriatic, as it is still popularly called). You will also find several other bases or alkalies, such as caustic soda or sodium hydroxide (or hydrate), caustic potash or potassium hydroxide (or hydrate, chemists are generous with names), sodium carbonate, and so forth.

Suppose we experiment awhile with our litmus, and the acids and bases; it is well worth the while. You note that *any* strong acid will turn the litmus *red,* and *any* strong alkali will turn the litmus *blue*; though it may take more of it and more time in some cases than in others. Then you take a little of some acid, vine-

gar for instance, in a tumbler. Slip a strip of litmus down the side, and pour in limewater. Soon the one will "kill" the other, and you can get both dead (or "neutralized" as the wise folk say) by mixing just enough of acid and alkali together; though at first you may pour in too much limewater to the vinegar, or not enough, and you will have to coax and tease the solutions back and forth, until you get them so that perhaps a drop or two will do the trick, and the litmus is neither red nor blue, but a sort of purple. That is the *neutral* point. Now if you taste these neutralized solutions, you will get neither the sharp taste of acids, nor the flat but peculiar taste of alkalies; as a rule, you will get a taste something like common salt, as tastes run; in fact, the things made by mixing acids and alkalies (or bases, for alkalies are only the more soluble and stronger bases) are "salts," and common salt is only the commonest salt.

This common salt can be made by mixing some soda with hydrochloric acid, until the exact point of neutrality is obtained; and, of course, it is a simple thing to evaporate some of the mixed and neutralized acid and alkali down to dryness, and thus collect some of it. Now there are millions of possible salts, and some thousands of these are known, and some hundreds of thousands remain to be found and to be used; but we will not bother about more than a few of them. We have too much to do with that bad boiler water to fool time away in what does not concern us. What we want to get at is that hardness, and to find out whether it is of the temporary kind, or of the permanent kind, and whether we can help the "boss" get rid of it in some cheap and practical way. For you will find out that there are two or three principal kinds of salt that bother the poor furnaceman almost to death, and they are mostly salts of this alkaline base, lime, that you have started to study.

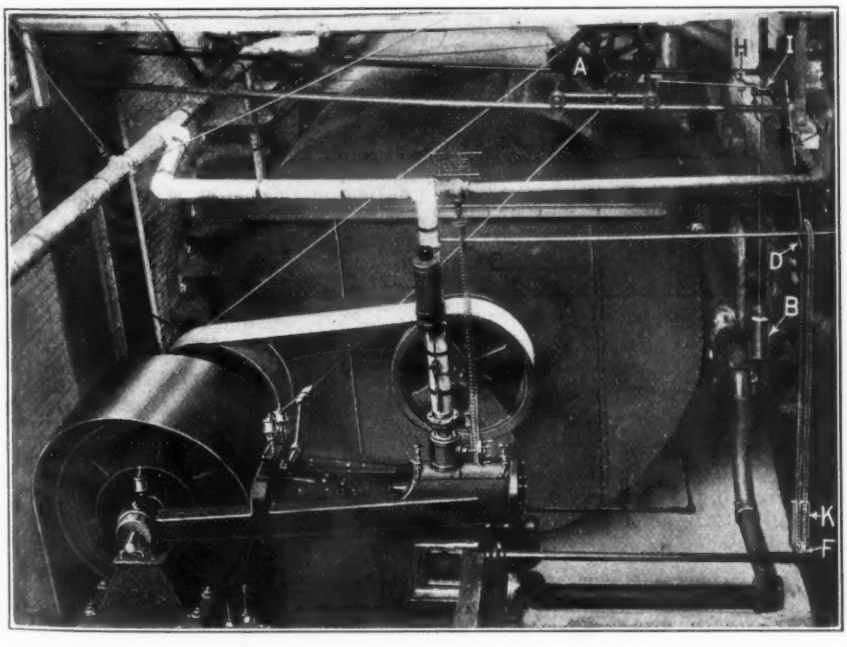


FIG. 1. APPARATUS FOR CUTTING OFF THE ENGINE AND TAKING UP SLACK ON A ROPE DRIVE

Ingenious Automatic Cutoff for Rope Drive

The W. F. & John Barnes Company, of Rockford, Ill., having a limited space in which to locate its heating apparatus, was forced to put a rope drive between the engine and the blower, as shown in Fig. 1.

In order to take up the slack of the rope caused by its natural stretch or the changes in atmospheric conditions, one strand of the rope was carried over a sheave wheel on the carriage *A*, which is located on a track above the engine. The weights *B* were hung on a rope that was passed through the pulley *C* and attached to the carriage *A*. This keeps the proper tension on the rope drive.

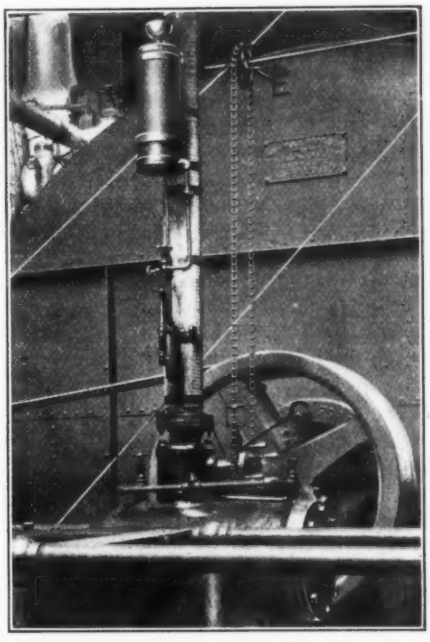


FIG. 2. CONNECTION ON THROTTLE

As the engine was not watched very closely, but was left to run itself, there was danger of the rope breaking, which would cause the engine to run away when relieved of its load. To overcome this an ingenious arrangement of sprockets *D*, *E*, *F* and *G*, with their chains and rods, was rigged up. If the rope in the drive broke, the carriage *A* would be run back to the fork *H* by the weights *B*. The carriage striking the fork *H* would move the rod levers *I* and *J* and these in turn would release the sprocket wheel *D* and its shaft, which would allow the weight *K*, that is fastened to the chain, to drop to the bottom of the sprocket wheel *F*. When the weight *K* drops it carries the chain with it and transmits this motion back to the throttle at *G*, Fig. 2, thus closing the throttle and cutting off the steam, which will cause the engine to stop.

This is a simple and cheap rigging that can be easily installed, but it does its work perfectly and might be useful to others if placed in a similar position through lack of space.

Power Costs in a 5000-Kilowatt Central Station

By H. S. Knowlton

The study of power costs in a modern central station throughout a period of years usually affords opportunity to determine the factors of chief importance under the prevailing conditions, in their bearing upon the efficiency of current production. An example of this is afforded by the following record of four years' cost of power in a New England central station of about 5000 kilowatts normal capacity. The figures cover consecutive years from 1905 to 1908, inclusive. During this period the equipment of the plant remained substantially unchanged until 1908, when a new station was begun by the company on a site adjoining the older installation. Part of the output for the last year shown was generated by the new plant, which will ultimately supersede the older station.

The equipment of the plant in 1905 consisted of a boiler installation of 1651 total horsepower, and an engine equipment of 4700 horsepower. There were 13 Scannell & Whaley boilers with Jarvis setting, each having a shell diameter of 72 inches and 140 tubes 3 inches in diameter, rated at 127 horsepower each, and operated at an average steam pressure of

120 pounds per square inch. The engine equipment was as follows: One Harris, 22 and 22 by 48-inch, 78 revolutions per minute, 750 horsepower; one Harris, 18 and 30 by 42-inch, 84 revolutions per minute, 500 horsepower; one Harris, 18 and 30 by 36-inch, 96 revolutions per minute, 450 horsepower; one International Power Company, 19 and 44 by 48-inch, 100 revolutions per minute, 750 horsepower; three Brown, 22 and 40 by 48-inch, 100 revolutions per minute, 750 horsepower. The electric-generating equipment of the plant consisted of 10 generators ranging in size from 135 to 675 kilowatts.

The total energy generated in the plant during 1905 was 5,354,000 kilowatt-hours. The company sold 1,409,000 kilowatt-hours for power purposes, which was an important factor in economical generation through its effect on the station-load factor as a whole. The company burned 7857 tons of New river coal, costing on the average $4.28, the fuel consumption per kilowatt-hour being 3.29 pounds. The operating force of the station consisted of three engineers, four oilers and cleaners, three firemen, two coal passers, three dynamo and switchboard men, two repairmen and one station clerk. The operating cost was as follows, omitting cents in total figures:

Coal or other fuel	$33,622
Rentals, station real estate	120
Oil and waste	561
Water	1,056
Wages at station	17,020
Station repairs	5,594
Steam-plant repairs	9,655
Electric-plant repairs	621
Station tools and appliances	1,562
Total	$69,814

Per kilowatt-hour the principal costs are fuel, 0.63 cent, and wages at station, 0.318 cent.

The equipment of the station was the same during the next year as in 1905. The cost of coal per ton increased to $4.42, and the plant consumed 8328 tons. The output was 6,038,000 kilowatt-hours, and the power sales 1,772,000 kilowatt-hours. The company's efforts to increase its power business enabled the machinery to be run at better loads during the daylight hours, when the demand upon the plant for lighting current was the least. The station force was practically the same, with the addition of one man, as in 1905. There was a saving in fuel consumption of about 0.2 pound of coal per kilowatt-hour. The total fuel cost was $36,820, or 0.61 cent per kilowatt-hour. The wages cost was $17,296, or 0.286 cent per kilowatt-hour, and the total cost of manufacture was $71,021, or 1.18 cents per kilowatt-hour. There was a saving of about $5000 in station repairs compared with the previous year.

In 1907 the equipment of the plant was practically the same as in the preceding two years. The output increased to 2,196,000 kilowatt-hours. The station was operated by seventeen men and the cost of coal rose to $4.55 per ton. The total fuel consumption was 9869 tons. The total fuel bill came to about $45,000, or 0.635 cent per kilowatt-hour. The labor cost was about $17,450, or 0.247 cent per kilowatt-hour, and the total cost of manufacture was $69,000, or 0.975 cent per unit produced. There was a reduction this year of about $9000 in steam-plant repairs. Other items showed less variation. The total repairs of station, steam and electric plants came to about $3400.

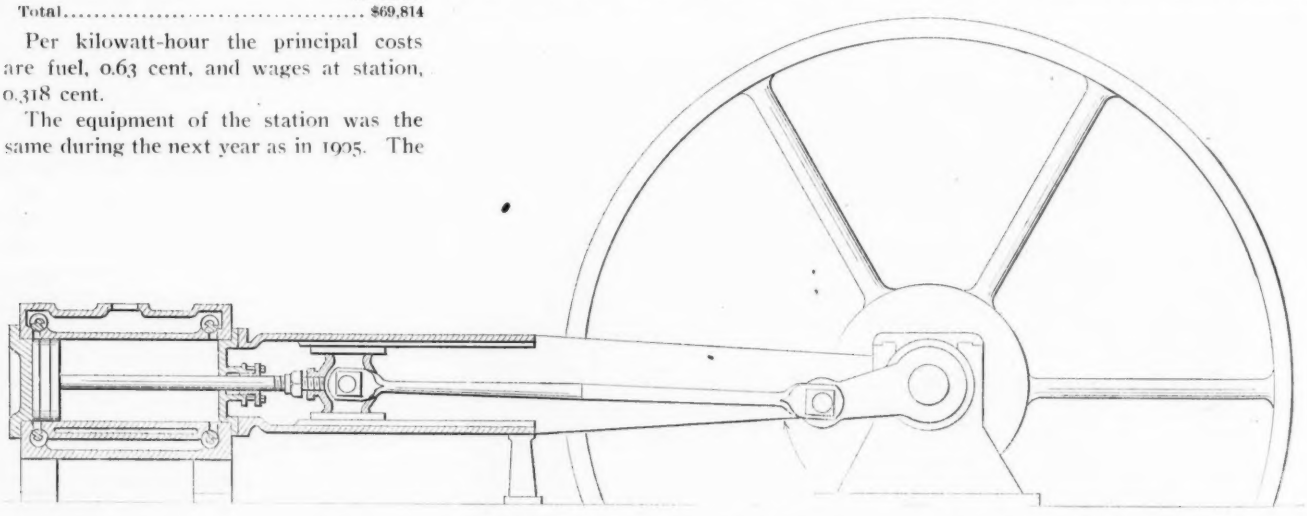
For the last year of the station record, 1908, the cost of fuel per ton increased to $4.75. In this year the initial installation of the new plant was opened for service, and this consisted of a 2000-kilowatt Curtis steam turbine, with three Stirling boilers having each three hundred and ten 3¼-inch tubes, operated at 180 pounds and rated at 526 horsepower. The total boiler capacity was thus increased to 3229 horsepower, and the total engine and turbine horsepower to 7200. The coal consumption was 14,101 tons, and the station force was five engineers, four firemen, six station electricians, ten boiler-room men and two repairmen. The fuel cost in toto was $67,000, and the advance in price per ton tended to increase the cost per kilowatt-hour to 0.71 cent. Station wages came to $24,700, or 0.262 cent. per kilowatt-hour, and the total manufacturing cost per kilowatt-hour was 1.06 cents, the amount expended for power production being $100,000. The energy generated by the station was 9,426,000 kilowatt-hours. The other items of production cost were not altered to any considerable extent compared with those of the previous year.

Summing up the history of the station during the period considered, there has been a progressive increase in the cost of coal, which is a serious obstacle to the economical production of power with a fairly stationary equipment. This has been offset to a considerable degree in the plant by careful operation, and particularly by the increasing of the power load each year. At the end of the four years this had increased to 3,760,000 kilowatt-hours, or 2.7 times the power sales of 1905. The steadying effect of such an output is inevitably a great help toward the operation of station apparatus at points nearer their most efficient output. That the cost per kilowatt-hour should have been reduced from 1.3 cents to about 1 cent in this period indicates that the plant has been operated with skill, in the face of high fuel costs and not the most modern equipment.

Two Loose Nuts

By W. H. Wakeman

The engineer of a certain plant reported that his engine pounded badly for a portion of the time, then would run quietly until for some reason the pound returned,



LOOSE CHECKNUT AND PISTON PARTLY UNSCREWED FROM THE CROSSHEAD

and this disagreeable condition of affairs annoyed him for several days. If the pound had been continuous the cause would undoubtedly have been found with little delay and trouble, but the intermittent action constituted a puzzle that baffled his efforts. Another engineer was called in for advice, and he proceeded to give the machine a thorough examination. He found the piston rod screwed into the crosshead in the usual way, but the check nut was loose, and this allowed the rod to

turn in the crosshead. It would unscrew until the piston struck the cylinder head at every revolution, causing a heavy pound, but for some unaccountable reason nothing was bent or broken.

The rod would then screw into the crosshead until the usual clearance on the head end was restored, consequently the pound disappeared. As the nut was frequently in contact with the crosshead when the engine was shut down, the defect was not discovered by the regular engineer.

In another case the same defect caused trouble, but in this instance much heavier blows were struck on the cylinder head when the crank was about to pass the inside center, as shown in the illustration. The engine was promptly shut down, the defect discovered, and both rod and nut were returned to their proper places, with but little delay in the operation of the machinery.

Shims had been placed between the end of the connecting rod and the corresponding half of the wristpin box, and these were forced together until a more perfect fit was secured for the surfaces in contact, by the great stress brought to bear on them by the toggle-joint action of the crank while in the position illustrated, in connection with the leverage of the flywheel. When the engine was started again there was a slight pound at the wristpin, although this box gave no evidence of lost motion before the accident. It was necessary to readjust the wedge at this point in order to restore normal conditions.

The joint made by joining the frame to the cylinder began to leak steam soon afterward, and when at attempt was made to tighten the nuts at this point, three studs were found broken in two, or pulled apart by the great strain that had been brought to bear on them. Fortunately the remainder proved sufficient to carry the load, thus preventing more serious trouble, but it was a very narrow escape.

This method of fastening a piston rod is preferred by many engineers because it admits of easy and accurate adjustment at all times, and allows the piston to be removed from the cylinder with little trouble. Do not use a pipe wrench on the piston rod to turn it out of the crosshead, as a certain engineer did, but turn the check nut back as far as it will go on the threads, then apply the solid wrench which is supplied by the engine builders for this purpose.

Great care should be taken to fasten the nut securely when the rod is returned to its proper place. It is not sufficient to put a wrench on it, then allow the fireman to sit on its short handle, but several smart blows with a hammer of suitable weight ought to be struck near the end of it, as the shock so produced is equal to, or better than, the operation of a long lever under steady weight or pressure.

Production of Electricity by Peat

By E. Hoffmeister

Peat exists in large quantities in Europe and America. In some sections of the United States, as in Michigan, for instance, the peat deposits are covered by woods, shrubbery or swamp, and are sometimes 40 feet in depth, rarely more. Wet peat contains from 80 to 90 per cent. of water and is dark brown, nearly black.

In order to prepare peat for fuel it has to be dug, formed into rectangular strips or blocks, of cross-section about the size of a tile, and dried in the open air. These operations may be wholly done by hand or partly by machinery. In the latter case the peat is dug by hand, carried by a conveyer to the press or mixing machine, where its fibrous structure is separated and expelled in the form of strips about 5x5x15 inches in size. These are piled on the ground for some weeks to dry. They are laid crosswise in a pile about 2 feet high, which permits the air to circulate around them, and in this way they become thoroughly dried, when they are ready for use.

Dry peat is dense and hard, like tile, is very inflammable and produces little smoke and ash. Its thermal value is about from 6300 to 7200 B.t.u. (if containing from 15 to 20 per cent. moisture), or practically one-half the thermal value of high-grade coal. The material when free of water is composed of 60 per cent. C, 5 per cent. H and 35 per cent. O.

The use of peat produced in the manner outlined has two marked disadvantages: (1) The drying process is dependent upon the weather. In Europe, for instance, the production period usually only extends over 100 days a year, and the capacity of the plants is very small; in fact, 10,000 tons a year is considered a very high output. (2) Transportation costs are in proportion to the weight, not the thermal value, and this means paying twice as much freight, compared with coal, for the same amount of heat. Therefore, peat is in general more expensive than coal.

Careful investigations have led to the following conclusions: It is better to bring the factory to the peat than the peat to the factory, and save the cost of transportation. Also, it is more profitable to use wet peat for fuel, as this permits the plant to be operated the year round without regard to the weather.

Producing Electricity from Peat

In certain parts of Europe, in producing electricity from peat, either of the following methods is used:

(a) Gas is made in a producer and burned in a gas engine. For the most part dry peat is used, but it is possible to use wet peat, of from 40 to 50 per cent. moisture. The producers are not unlike those used with coal, and are usually the patents of firms which have been engaged in this line for years. Peat-gas producers are built by Luther in Braunschweig (Germany), Benz in Mannheim and Körting in Hanover. The thermal value of the gas is from 1900 to 2160 B.t.u.

(b) Wet peat is placed in a boiler, where its moisture (80 to 95 per cent.) is evaporated and superheated and employed in driving a steam engine or turbine. The residue is dry peat, which is automatically ejected and burned under the boiler. Thus, while some dry peat is used it only requires about one-eighth as much as though dry peat were used altogether. A wet-peat plant of 4000 horsepower is in course of construction to supply light and power to the towns of Emden and Wilhelmshafen and fifty other places within a radius of thirty miles. The engine and boiler are to be furnished the Maschinenbau Gesellschaft, Nürnberg.

These two methods are comparatively new. The difficulty with the first is to produce a gas free of tar. This would not be difficult ordinarily with dry peat (of 20 per cent. moisture), but in the case under discussion the process is expensive and the peat exists in small quantity. The objectionable feature of the second method is the complicated boiler.

Peat Problem in the United States

Under present conditions in the United States the peat problem is not very important. Coal is cheaper and wages higher. When the United States becomes more densely populated the problem will be ripe for discussion and solution. Americans have to use the experience of the old country, as yet, and it would be a waste of time to try new methods. The only chance for improvement is to substitute machinery for hand labor, and perfect the machinery.

The peat problem seems very simple but, in truth, it is quite the reverse. Millions have been risked and millions have been lost, but it is also a fact that experienced producers make big profits with small investments.

In the inquiry on "Path of Point on Connecting Rod," published in the December 29 number, page 1109, formula (1) and the last formula used in the answer were not printed according to copy. Formula (1) should read,

$$3.1416\sqrt{\frac{D^2+d^2}{2}},$$

and the substitution of figures made in the formula should read,

$$3.1416\sqrt{\frac{18^2+12.3^2}{2}}=48.38.$$

The answer was given correctly, but it would undoubtedly be a source of wonder how such a result was obtained from the expression as printed.

POWER AND THE ENGINEER

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Municipal Ownership

We give place to a letter on "Municipal Ownership," by Arthur Williams, in our correspondence columns, despite the fact that we are not interested in the question, which is a sociological rather than an engineering one. POWER's subject is engineering and not political economy.

The clipping from the Wisconsin paper, to which the editorial which called out Mr. Williams' letter refers, says that "a city cannot run a lighting plant as cheaply as private companies can supply the light." The subscriber who sent it asked for our opinion upon this question, which, divested of politics, is an engineering one; and after a careful consideration of Mr. Williams' contention we should still answer it as we did before. The boilers, engines and generators do not know nor care who owns them. Put them into the hands of an equally good man, give him a free swing and hold him responsible for results and they will produce current for the people as cheaply as for a corporation. The additional dividends which it is necessary to pay upon watered stock, franchise valuation, corruption funds, etc., may be put against the increased costs due to political graft, etc., of which Mr. Williams protests—but this is getting out of the engineering side of the case.

The business of producing electricity is getting systematized. The cost of plant per kilowatt, the cost of putting current upon the switchboard, the cost of distribution are becoming known and a free exchange of data among such plants and the publication of uniform reports, as is done by water-works engineers, would make a particularly extravagant station stick out like a sore thumb, whether it belonged to the public or to an individual.

Please remember that a continuation of this discussion must be along engineering and not socialistic nor political-economical lines.

The Gas Engine Engineer

Repeatedly the assertion has been made that the average stationary engineer does not develop into as efficient a gas engineer as the ordinary machinist, although why such a view of the matter should be taken is not always definitely stated. The average machinist has the advantage of knowing how to repair or even make a part of a machine in case of breakdown. He has a better knowledge of the use of tools, if he is a man of experience, but it is difficult to see how these accomplishments are such strong points in his favor as to put the steam engineer out of the race. The machinist's one real advantage over the steam engineer is that he does not know how to run a steam engine; this can be considered advantageous because, not knowing anything about the operation of any type of engine, he is more likely to feel receptive toward advice and instruction.

The steam engineer is familiar with the operation of both steam and gas engines, as far as the reciprocating parts are concerned, but in the matter of the action of the power medium he is familiar only with steam. Of the action of gas in an engine cylinder he has much to learn—as much as, if not more than, the machinist, because there is liability of his confusing the manner of regulating the effect of exploding gases with that of steam expansion. In the matter of adjustments the engineer should be at home; in the care of bearings, the same vigilance is required as with steam engines, and no more.

With all the good things that may be said in favor of the steam engineer as a candidate for gas-engine honors, however, he is handicapped in one particular. He is familiar with steam-engine operation and expects to obtain the same results from a gas engine. This is something that cannot be done. It is no uncommon thing to see a steam engineer fret and worry because his engine has developed a pound or some little thing out of the ordinary; such an engineer will not rest contented until that fault is found and remedied. His greatest ambition is so to adjust his engine that it will operate practically without noise, and in some cases this is carried so far as to become almost a mania. There is a good deal of satisfaction in having a smooth-running engine, and the engineer is excusable if he is a trifle "finicky" on this subject. When it comes to running a gas engine, noiseless operation is a snare and a delusion to an operator who has fond dreams that its operation is to be a round of pleasure. He expects almost noiseless operation, and gets rattling and sometimes clanging. He listens for a modest click by the valve gear and hears the whacking of the cams and the muffled thump of the valves as they seat. The smooth-running engine which was expected is not in evidence, and then the steam engineer makes his mistake; he attempts, by adjustments here and there, to make the gas engine operate as quietly as a steam engine. As the functions of the different devices on the gas engine are not at first fully understood, it does not take long for him to get the adjustments so out of place that the engine refuses to work properly, and serious trouble ensues.

Here, then, is the chief difference between the two candidates. The machinist, not expecting any particular sounds from the engine, accepts the noises of operation as he finds them, and consequently does not meddle with the adjustments until he has so familiarized himself with the working of the engine that he knows what he is about. If a steam engineer will not demand of the gas engine that which it cannot give, and will leave all adjustments alone until he under-

stands what the effects of making them will be, he will be able to hold his own against all comers.

Compression

Some months ago there were received from a small town in Oklahoma two sets of indicator diagrams. One set was of the conventional type of Corliss-engine diagram, with the compression curve rising to about two-thirds the initial pressure and with plumb-line induction, showing ample lead of steam valves and full pressure on the piston while the crank was still on the center. The other set from the same engine showed only a little rounded heel of a compression curve and the admission line inclined toward the middle of the diagram, showing plainly that the piston had actually moved a measurable distance before full steam pressure was realized in the cylinder.

These second diagrams were not good-looking, as handsome diagrams are usually considered, and computation showed that the indicated horsepower was considerably less in the case of late steam-valve opening and lack of compression than it was where ample steam lead had obtained and all of the lost motion in pins and journal was taken up by plenty of compression. But the engineer said that the actual load, that is, the useful work that the engine was doing, was the same in both cases, and asked why less steam was used to do the work with the one style of valve setting than with the other. The answer that was given him said in substance that the reduction of pressure on pins and main journal reduced the friction of the engine and thus decreased the load to be carried and consequently reduced the quantity of steam used per brake horsepower per hour.

Attempts were made to get one or two mechanical-engineering professors interested in the matter, to the extent of experimenting on an engine with a fixed load with different valve settings, with rather discouraging results. It was said the steam in expanding gives up to the piston all of the energy expended in the compression and it makes little or no difference as far as economy is concerned whether an engine is operated with or without compression.

These excathedra statements have a tendency to create a feeling of antagonism in the mind of the average operating engineer toward all technically educated men. Some engineers know from experience that there is a slight loss if compression is carried above the terminal pressure, while others feel that there is really a gain made by carrying the compression line to about one-half or two-thirds of the boiler pressure.

Most of the mechanical-engineering laboratories of the universities of the country are equipped with engines fitted to decide this question by scientific investigation. It could be shown whether an engine with a constant brake load, such as could be readily measured, would use more or less steam with one form of valve adjustment than with another. Pounds of steam per indicated horsepower-hour, pounds of steam per brake horsepower-hour and the indicated horsepower necessary under different valve setting to carry a certain brake horsepower are questions that are of vital interest to the designing as well as to the operating engineer, and only in the laboratories of the technical colleges of the country is the apparatus suitable for making an exhaustive test to be found. Can the men at the heads of these experiment stations determine these things?

Some years ago some experiments along this line were made in Belgium and although they were incomplete, owing to the fact that the engine used "did not lend itself readily to compression," the conclusion reached was that compression of exhaust steam in the clearance space resulted in a direct loss.

At many of the universities are engines which will readily lend themselves to compression. Can one or more of these engines be pressed into the service of settling for the operating engineer, who has no opportunities for satisfactory experiment, the question of whether compression leads toward economy or away from it?

The Engineer and the Central Power Station

Successful steam-engine operation means a great deal beyond the running of a steam plant at its highest efficiency. Not alone should the engineer seek to keep his plant in the best of operating condition, but he should also see to it that nothing that may be of advantage to himself or the plant escapes his attention.

In its search for business the central power station is competing with the isolated plant and through its management attempting to show the small-plant owner that business wisdom indicates that it is better and cheaper to buy power than to attempt to make it. Whether this is true can be better determined by the engineer of the small plant than by anyone else in the world.

In a manufacturing town a new engineer of a large building found several of the tenants buying both power and light from the central station and the prospect was good for more business for the central plant. After thoroughly familiarizing himself with all of the details of the situation he went to the proprietor and said:

"You have an engine furnishing power and lights to some of your tenants. The proper thing to do is to furnish all the power and all the light to all of your tenants. You have an engine running at sixty revolutions a minute and it is fully loaded. This speed should be increased to one hundred revolutions, and it can be with perfect safety. This will give you an increase of forty per cent. in power, which will enable you to take over all of the load that is being carried by motors with current from the central company. I know how many lamps are being used and the size of dynamo needed to light them. Buy and install this and change the speed of the engine, then I will say to your tenants: 'You are paying thirteen cents per kilowatt-hour for current to light your rooms. I am prepared to furnish this light to you for eight cents.'

"Soon I will have a full load for the engine without costing you one cent for extra coal. For seven months of the year you have to heat the buildings, so it will cost you practically nothing to run the engine and the revenue from the lighting will pay a big rate of interest on the outlay."

The proprietor was skeptical, but finally consented to the change. At the beginning of each month the engineer laid his reports before the owner. As time went on the revenue from the lights, which had been applied directly to the liquidation of the coal bill, began to show a surplus. One day when the reports were being examined, the engineer said:

"You see that the coal bill last month was six hundred and some odd dollars, while the amount collected for lighting amounts to more than seven hundred dollars. From these figures you can readily see that you do not need to worry any over my salary. The Central Lighting and Power Company is paying that about four times over every year."

And being asked to explain, he said:

"Before I took this plant you were burning just as much coal as you are today. Steam was needed to heat the different buildings and, as not enough went through the engine, lots of steam direct from the boilers was used.

"The engine has been speeded up and more load put on and the exhaust used for heating. The extra load came from the lights and power that were taken from the Central company. The money that your tenants paid that company is now paid to you and it is all, except a small interest and depreciation charge, 'velvet'. It comes from money that formerly went to the Central; it costs you practically nothing. I have made it all for you. I have shown you that I am a source of revenue to you. I want a part of it, because I am worth it, and because, as I said, it all comes out of the Central company."

The Weighton Air Gage

In steam-engine practice the losses resulting from air leakage in the condenser system have been guessed rather than calculated. In order that the engineer may determine at a glance the amount of air being discharged an air pump may be

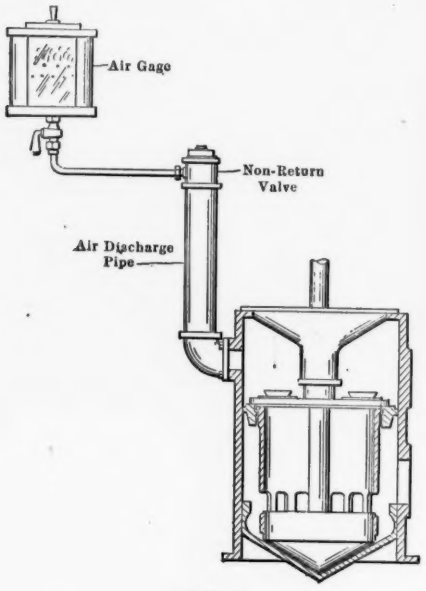


FIG. 1

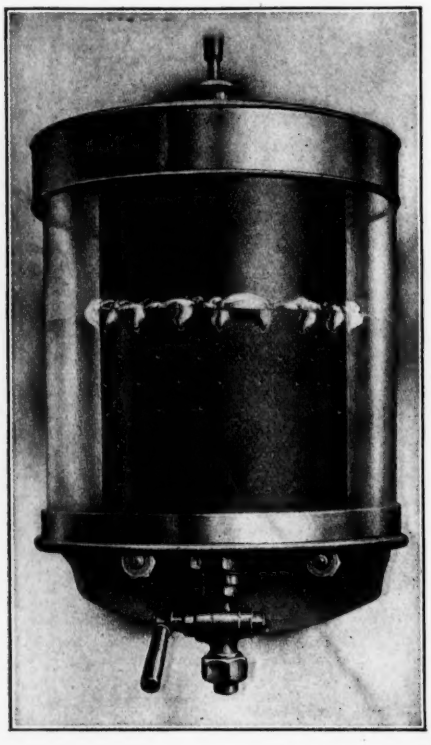


FIG. 2

fitted with a Weighton air gage. It is a glass cylinder, closed at the bottom and containing a stationary bell, the interior of which is in communication with the air-discharge pipe of the air pump. See Fig. 1. Around the surface of the bell are several rows of holes, as shown in

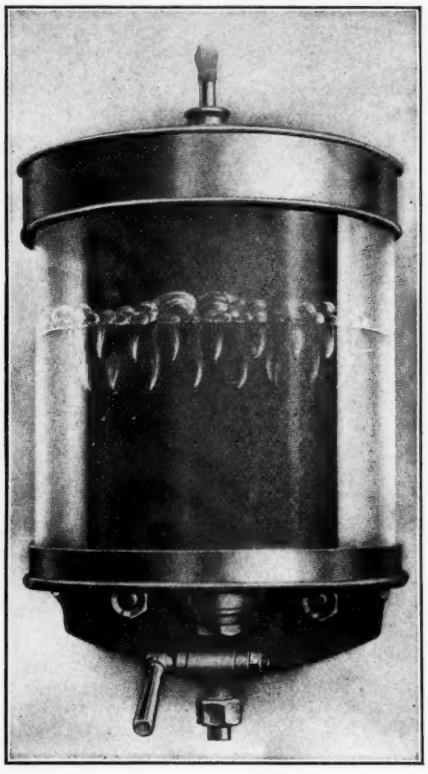


FIG. 3

Fig. 2. The outer cylinder is filled with water to a point where it will just cover the highest row of holes. When air is admitted, even under very slight pressure, the water level is depressed below the top row of holes and air escapes through them. As more air is admitted to the bell the water is correspondingly depressed and additional holes are exposed. As original calibrations have been made, the number of cubic feet of air being discharged under any given condition is easily ascertained, while the relative amount of air being handled by the air pump is shown by the condition of the air gage (Figs. 3 and 4). The device is the invention of R. L. Weighton, professor of electrical engineering at Durham College of Science, Newcastle-upon-Tyne, England. It will be introduced in this country by the Elwold Company, North American building, Philadelphia, Penn., which also represents the Contraflo Condenser Company, Ltd., of London.

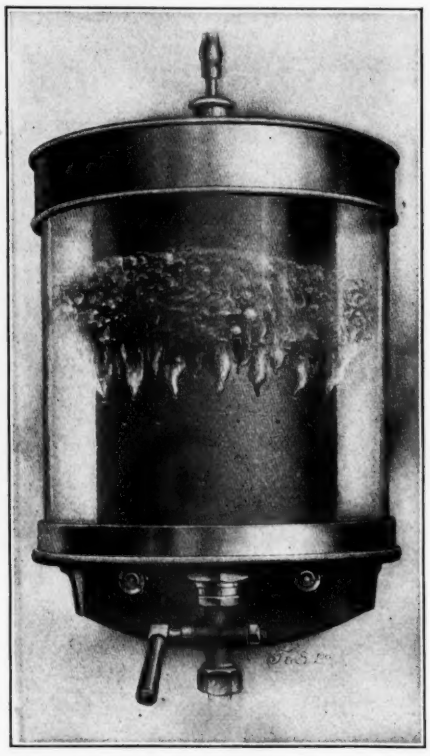


FIG. 4

Museum of Safety and Sanitation

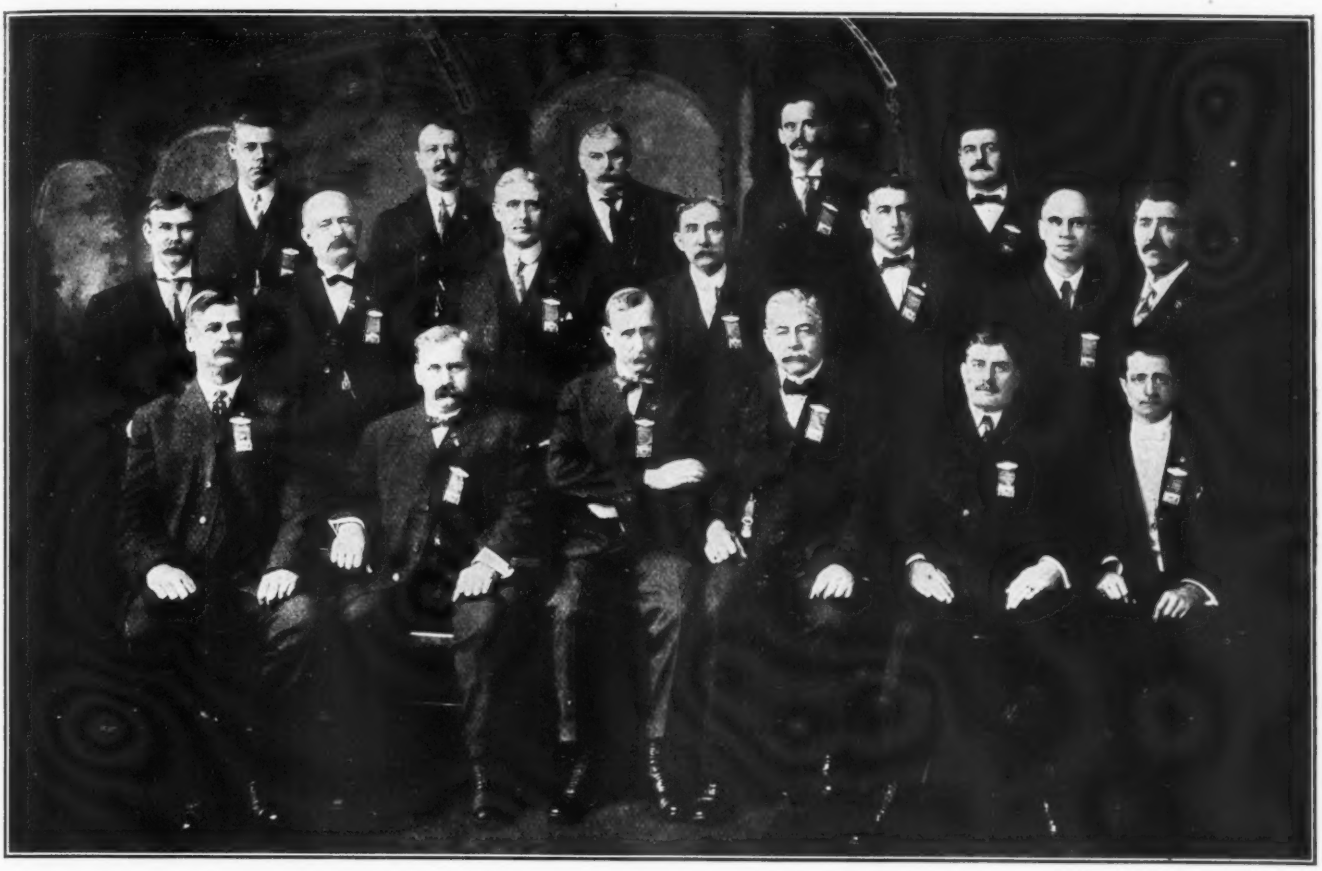
Announcement has just been made of the acceptance of the treasurership of the Museum of Safety and Sanitation by Frank A. Vanderlip. An executive office for the administrative and promotive work of the museum has been opened at the United Engineering Societies' building, 29 West Thirty-ninth street. New York City.

A committee on plan and scope includes Prof. F. R. Hutton, chairman; Dr. Thomas Darlington, commissioner of the health department of the City of New York; P. T. Dodge, president of the Engineers' Club; William J. Moran, attorney-at-law and Henry D. Whitfield, architect.

Plans are being pushed forward along practicable lines to prevent the enormous loss of life and limb to American life and labor, through the Museum of Safety and Sanitation, where safety devices for dangerous machines and preventable methods of combating dread diseases may be demonstrated. Charles Kirchhoff, editor of *The Iron Age*, is the chairman of the committees of direction; T. C. Martin, editor of *The Electrical World*, vice-chairman, and Dr. William H. Tolman, director.

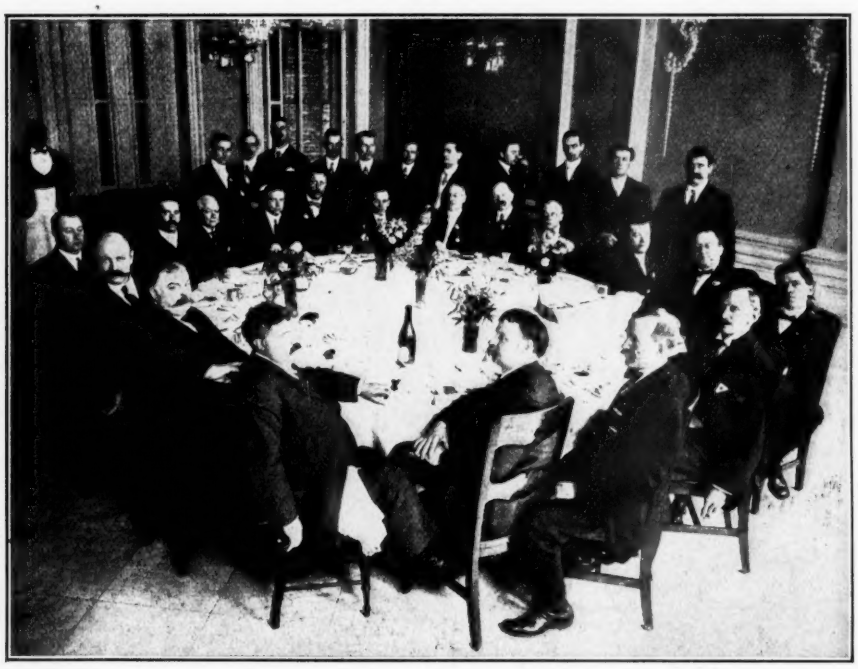
Street and Electric Railway Power Plants

In a preliminary report on street and electric railways in the United States, exclusive of Alaska, Hawaii, Philippine islands and Porto Rico, the Department of Commerce and Labor shows that for the year ending December 31, 1907, there were 827 power houses, 2,384,518 horsepower of steam and gas engines, including turbines, or 2552 units in all, and 228 water wheels, aggregating 91,961 horsepower, employed in the street-railway business. These figures represent 2.7, 83.4, 8.5 and 42.5 per cent. of increase, respectively, over the year ending June 30, 1902.



GROUP OF OFFICERS AT NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION CONVENTION AT WASHINGTON, D. C., JANUARY, 1909

DELEGATES AT NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION CONVENTION AT WASHINGTON, D. C., JANUARY, 1909



NEW YORK DELEGATION TO NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION CONVENTION AT WASHINGTON, D. C., JANUARY, 1909

Bulletin No. 26, "High Steam Pressures in Locomotive Service," has just been issued by the University of Illinois Engineering Experiment Station. It summarizes the results of one hundred locomotive tests conducted by Dr. W. F. M. Goss under the patronage of the Carnegie Institution in coöperation with the authorities of Purdue University. The general question is discussed as to whether a possible increase in the weight of a boiler should be utilized by making the boiler stronger that it may carry a heavier pressure, or by making it bigger that it may have more heating surface. The conclusion is to the effect that single-expansion locomotives using saturated steam are most efficient when operated under a boiler pressure of 180 pounds; that when this limit of pressure has been reached, any farther increase in weight which may be possible should be utilized in securing increased boiler capacity rather than higher boiler pressures. Copies of this bulletin may be obtained gratis upon application to the director of the Engineering Experiment Station, Urbana, Ill.

The American Anti-Accident Association, with headquarters at Sharpsville, Penn., will hold open meetings, afternoon and evening of Thursday, February 11, in the Y. M. C. A. hall, 215 West Twenty-third street, New York City, for the delivery of addresses and considering of ways and means to prevent accidents. In order that all classes may have a hearing the society extends a general invitation to Government and municipal officials, professional men and women, commercial travelers, manufacturers, managers and superintendents, merchants, labor leaders, mechanics, etc., factory inspectors, fire and life insurance officers, teachers and all other citizens who may be interested in this work, to attend both sessions of these public meetings.

NATIONAL MARINE ENGINEERS SUPPLYMEN'S ASSOCIATION AT THE CONVENTION AT WASHINGTON, D. C., JANUARY, 1909

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Using a Motor as a Dynamo

Can I use a 500-volt direct-current motor as a 110-volt dynamo? If so, what changes are necessary?

R. M.

No; not without completely rewinding the field magnet and armature. You can use the machine as a 500-volt dynamo by discarding the starting box, putting a rheostat in the field-winding circuit and driving the armature at a speed about 10 per cent. higher than that at which it runs as a motor.

Reversing a Compound-wound Dynamo

What changes are necessary in order to permit driving a compound-wound direct-current dynamo in the reverse direction of rotation?

G. W. McF.

Transpose the cables leading from the brush holders to the terminal block, making the change at the brush-holder ends in order to avoid accidental disturbance of some other connection. Then reverse the brush holders so that they extend from the studs in the opposite direction from the original one. That is, if they now "trail" with respect to the travel of the commutator, they should be turned around so that they will "trail" when the rotation is reversed. Carefully avoid making any changes in the connections of the field-magnet windings.

Power Value of Different Gases

What is the effect of the kind of gas used in an engine upon the power of the engine? That is, will rich gas give more power than poor gas?

J. T. M.

The maximum ability of an engine of given piston displacement is somewhat higher with rich gas than with poor, but not in proportion to the heat value. It is the heat value of the mixture that really determines the performance, and rich gases require so much more air than poor gases that the mixture is not as much richer as you would think. A good mixture of natural gas and air has only about 50 per cent. more heat value than a good mixture of producer gas and air, although natural gas has about seven or eight times the heat value of producer gas.

Ratio of Expansion

Will you please tell me what is ratio of expansion and how is it found?

M. D.

Ratio of expansion is the proportion the total volume of the steam in the cylinder at the end of the stroke bears to the volume at cutoff. To find the ratio of expansion divide the stroke in inches by the number of inches of the stroke completed when cutoff takes place. To be exact in calculating the ratio of expansion the clearance must be known and taken into consideration. If, for instance, the effect of the clearance is such that it adds 1 inch in length to the volume of the cylinder at each end, then this must be added to the stroke of the piston and to the distance the piston moves before cutoff. Suppose the stroke of the engine to be 30 inches and the cutoff to take place after the piston has traveled 6 inches, nominally the cutoff would be at 1/5 stroke and the ratio of expansion would be 5, but actually the cutoff would be 7/31 of the stroke and the ratio of expansion would be 4.428.

Effect on Cutoff, etc., of Shifting the Eccentric Center

What is the effect, on the cutoff, compression and lead, of shifting the eccentric center toward the shaft center when the point of suspension of the eccentric is located on the center line of the crank and the shaft on the same side of the shaft as the crank pin?

M. C. B.

Lead being understood as the distance which the valve has opened when the crank reaches the dead center, it would be affected by shifting the eccentric center toward the shaft center as follows: First, with the eccentric pin preceding the crank in the direction of rotation, the lead would be increased if the movement of the eccentric rod was reversed through a rocker arm; as is the case with some engines, and had an inside steam valve; that is, a valve which admits steam by the inner edge. Second, under the same conditions the lead would also be increased if the motion of the eccentric rod was transmitted direct to the valve through the ordinary carrier arm, and an outside valve was used; that is, one taking steam by the outer edge like an ordinary slide valve. Third, if the eccentric followed the crank in the direction of rotation, the lead would be decreased if the motion of the eccentric rod was reversed through a rocker arm and an outside steam valve was used. Fourth, with the eccentric following the crank the lead would be again decreased if the eccentric motion was transmitted direct through a carrier arm and an inside steam valve was used. The cutoff and compression would take place earlier under each and all of the above arrangements.

Amount of Injection Water Required to Condense Steam

Will you give me a rule or formula that will enable me to determine the amount of injection water needed to condense the steam from an engine?

T. W. L.

The quantity of water necessary to condense the steam from an engine depends upon the volume and total heat of the steam and the temperature of the condensing water. Let

H = Total heat in 1 pound of steam at terminal pressure,

h = Heat in a pound of water at the temperature of the condensed steam,

t = Temperature of condensing water entering the condenser,

T = Temperature of water leaving the condenser.

Then, the amount of water needed would be determined by the equation

$$\text{Quantity of water} = \frac{H - h}{T - t},$$

because the number of heat units absorbed by each pound of water will be represented by $T - t$ and the number of heat units taken out of each pound of steam will be represented by $H - h$.

From the formula the rule is deduced:

RULE—*From the total heat of 1 pound of steam at the given pressure, subtract the heat in 1 pound of water at the temperature it leaves the condenser. Divide this remainder by the rise in the temperature of the condensing water. The quotient will be the pounds of water needed to condense 1 pound of steam. This multiplied by the number of pounds of steam used by the engine will give the total condensing water required.*

In a general way, it may be stated that with condensing water at or near 70 degrees temperature and with a 26-inch vacuum, from twenty to thirty times the weight of water fed to the boilers will be required to condense the steam.

Changing Generator Frequency

I have an old-style Thomson-Houston 1100-volt 125-cycle generator and I should like to know if this or any other 125-cycle generator may be changed to 60-cycle by reducing the speed, say, one-half. I take it that the capacity would also be reduced one-half, but by keeping the voltage of the exciter constant, would not the machine do as good work at a lower frequency but with the same voltage? Of course, there are other things to be considered.

D. A. S.

The frequency can be changed to 60 cycles by reducing the speed to 48 per cent. of the rated speed. This, however, will reduce the voltage to 48 per cent. of the normal, or 528 volts. In order to avoid this the armature would need to be rewound with coils each containing 2.09 times the present number of turns of wire. This wire would be less than half the size of the present wire and the full-load current would be correspondingly reduced.

La Technique Moderne is the name of a new monthly devoted to applied science and published by Messrs. Dunod & Pinat, at Paris. Editorial direction is under M. Bourrey, inspector of technical instruction to the Minister of Commerce and Industry. The committee of editors contains many well known professional and scientific specialists, and the first number, that of December, 1908, presents a promising and creditable appearance.

Business Items

George T. Ladd has established offices at 1620 Farmers' Bank building, Pittsburg, Penn., as representative of the Bass Foundry and Machine Company, of Fort Wayne, Ind.

The York Manufacturing Company, York, Penn., manufacturer of ice-making and refrigerating machinery, has received 26 recent orders aggregating 992 tons of refrigeration. One of these plants is for Yokahoma, Japan, Japan, and one for Smyrna, Turkey.

J. G. Aldrich, who was formerly with the Power and Mining Machinery Company, of Cudahy, Wis., has accepted the position of chief engineer of the Industrial Gas Power Company, of Milwaukee. Mr. Aldrich will continue to make a specialty of gas-engine and producer work, in which branch of endeavor he has been active for the past eight years.

The Larson Lumber Company, of Bellingham, Wash., has ordered from the Minneapolis Steel and Machinery Company, a 22x42 Twin-City Corliss engine. This engine will develop about 500-horsepower. It will have a flywheel 14 feet in diameter, grooved for twenty-four 1½-inch ropes. The machinery for the main drive has also been ordered from the same company.

The Rockwell Furnace Company has been awarded the contract covering the complete furnace equipment for the new locomotive shops of the Delaware, Lackawana & Western Railroad at Scranton, Penn. The furnace equipment consists of 35 of the latest-type furnaces operated with 300-B.t.u. water gas, which is made in Loomis-Pettibone producers. These shops will be capable of turning out complete locomotives, and are to be in operation in three months.

In order to take care of the increased business the L. J. Wing Manufacturing Company has increased its capital from $25,000 to $100,000 and has secured offices at its present address, the West street building, 90 West street, New York, twice the size of those at present occupied by them, and into which they expect to be removed by the 15th of February. While the ventilating business of the company has greatly increased, the principal increase is in the sales of the Wing "Typhoon" turbine blower made by this company.

The Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, maker of the Buckeye boiler skimmer, has received a letter from the Harris Toy Company, Toledo, Ohio, in which they say: "We have had in use for about a year one of your boiler skimmers, attached to our McNull water-tube boiler, and have found it a very profitable investment. Before putting on this device, we were obliged to clean out our water tubes every two or three weeks in order to keep up a satisfactory amount of steam. After installing your Buckeye boiler skimmer, we found it only necessary to clean our boiler once in three months and in opening up the tubes we find but very little mud and scale."

An attractive brochure is printed by the Keystone Lubricating Company, Philadelphia, bearing the title, "Grease versus Oil," and containing instructive comparisons of the efficiency of the two great types of lubricant that are used to grease the wheels of industry. Some of the inner reasons for the extensive use of the liquid lubricant, oil, at the present day, to do the work that should properly be done by grease, are interestingly explained. A feature of the argument for Keystone grease as an ideal lubricant, at minimum first cost and operating cost, is an account of exhaustive tests made by the head chemist of William Cramp & Sons, the Philadelphia ship-builders, on the chemical constitution and mechanical and anti-friction qualities of the product. This booklet, of which many thousands have been printed and distributed, may be obtained gratis on application to the home office of the company, Philadelphia, or to any of its agencies.

New Equipment

The Rogersville (Tenn.) Ice Company has been incorporated. Capital, $10,000.

The Empire Electric Power and Supply Company, Carthage, Mo., will enlarge plant.

The Spreckles Sugar Refining Company, Philadelphia, Penn., will erect a power house.

The question of a municipal electric light plant at Union, Ore., is under consideration.

The Concully (Wash.) Copper Mining Company is planning to install an electric plant.

The Holton Power Company is erecting a new power plant near the present one in Holtville, Cal.

The Alton (Ill.) Water Company is said to have decided to expend about $70,000 in improvements.

The City Council, Dodgeville, Wis., has under consideration the question of installing a municipal electric-light plant.

The Valley Power Company, Cashmere, Wash., proposes to increase its output. It is said about $125,000 will be expended.

Fred. C. Schaub, Cody, Wyo., has been granted a franchise to construct an electric-light and power plant in Meeteese, Wyo.

The Oelwein (Iowa) Light, Heat and Power Company is planning improvements to plant which will cost about $25,000.

C. D. McCarthy has been granted franchise by the City Council, Stevensville, Mont., to construct an electric-light plant.

The city of Bellevue, Iowa, proposes to rebuild the municipal electric light plant at a cost of about $7000. W. J. Fay, city clerk.

The Marengo Electric Light and Power Company, Marengo, Iowa, is in the market for a fire tube boiler 125 to 140 pounds pressure.

The citizens of Samson, Ala., voted to issue $25,000 bonds for construction of electric-light plant and water-works. W. J. Gresham, mayor.

The municipal electric-light plant at Oconomowoc, Wis., is to be enlarged, for which purpose an appropriation of $11,000 has been made.

The Crystal Coal & Coke Company, Godfrey, W. Va., is in the market for a second-hand power plant. About 400 k.w. in two units will be needed.

The Washington Power Company, Spokane, Wash., will soon begin the construction of a new $750,000 power plant at Little Falls on the Spokane River.

It is reported that the Laclede Gas Light Company, St. Louis, Mo., contemplates making extensive improvements at an expenditure of about $10,000,000.

The City Council, Plano, Tex., is making arrangements to establish a municipal electric-light plant. J. C. Skinner can give further information.

The Asheville (N. C.) Electric Company has under consideration plans for improvements and extensions including construction of new power plant.

The Yukon (Okla.) Mill and Grain Company will receive bids until Feburary 15 for water-tube boilers, pumps, Corliss engine, etc., as per specifications.

The Citizens' Electric Light and Power Company, East St. Louis, Ill., has been granted a franchise to construct and operate an electric-light plant.

The North Yakima & East Selah Irrigation Company, North Yakima, Wash., contemplates the installation of a pumping plant of about 3000 horsepower.

R. B. Flesch & Co., is said to have been granted a franchise by the town council of Fowler, Kan., for an electric-light plant, water works and ice plant.

New Catalogs

The Deming Company, Salem, Ohio. Catalog. Spray pumps and appliances. Illustrated, 32 pages, 5x8½ inches.

The Burt Mfg. Company, Akron, Ohio. Catalog. Oil filters, exhaust heads, ventilators. Illustrated, 96 pages, 6x9 inches.

National Meter Company, 84 Chambers street, New York. Catalog. Nash gas engines. Illustrated, 36 pages, 6x9 inches.

Leavitt Machine Company, Orange, Mass. Catalog No. 15. Dexter valve reseating machine. Illustrated, 22 pages, 7x8½ inches.

Industrial Instrument Company, Foxboro, Mass. Bulletin No. 11. Self-winding clock systems. Illustrated, 40 pages, 8x11 inches.

National Steam Pump Company, Upper Sandusky, Ohio. Catalog No. 29. Pumping machinery and air compressors. Illustrated.

The Casey-Hedges Company, Chattanooga, Tenn. Catalog. Water-tube marine and standard boilers. Illustrated, 80 pages, 7x10 inches.

H. W. Johns-Manville Company, 100 William street, New York. Catalog No. 100. Pipe and boiler insulation. Illustrated, 70 pages, 4½x7 inches.

Westinghouse Electric and Manufacturing Company, Pittsburg, Penn. Circular No. 1157. Type S distributing transformers. Illustrated, 16 pages, 7x10 inches.

The Bristol Company, Waterbury, Conn. Bulletin No. 100. Combination indicating and recording unit of Bristol electric pyrometers. Illustrated, 8 pages, 8x10½ inches.

The Yale & Towne Manufacturing Company, 9 Murray street, New York. Catalog. Chain blocks, electric hoists, trolleys and cranes. Illustrated, 70 pages, 6x9 inches.

Oil Well Supply Company, Boiler Works Department, Oswego, N. Y. Catalog. Water tube boilers. Illustrated, 30 pages, 6x9 inches. Circular. Horizontal tubular boilers. Illustrated, 12 pages, 8x11 inches. Circular. Locomotive type portable boilers. Illustrated, 8 pages, 8x11 inches.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—A good live agent in every shop or factory in the U. S. to sell one of the best known preparations for removing grease and grime from the hands without injury to the skin. Absolutely guaranteed. An agent can make from $5.00 to $25.00 over and above his regular salary. This is no fake. Write for free sample and agents' terms. The Klenzola Co., Erie, Pa.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION WANTED by a thoroughly competent and practical engineer. Long experience in erecting, installing and operating steam, water and electric power plants; capable of taking full charge of any plant. Am now holding good position under first class Massachusetts license, but desire to change. Best of references on application. Box 77, POWER.

WANTED—A position as master mechanic with coal and iron company. Fifteen years' experience with coal mine machinery, both steam and electric haulages; understand hand-

A New Lighting Station for Brockton

A Modern Alternating-current Turbine Plant Supplying 2200-volt A. C. Service and Direct-current Lighting through Rotary Converters

BY E. T. REED

To take care of increasing business and obtain a location where coal and water supply would be more convenient, the Edison Electric Illuminating Company, of Brockton, built a new power station in East Bridgewater to supplement an old plant in the heart of the city of Brockton. It was necessary in the old plant to run engines noncondensing. Coal and ashes had to be carted and city water used in the boilers. In the new plant the Matfield river supplies water for condensing and boiler feed, and coal is landed in the yard from a spur track from the New York, New Haven & Hartford Railroad.

The new plant was put in operation about a year ago. The building is of brick and concrete construction. The stack is self-supporting and made of steel

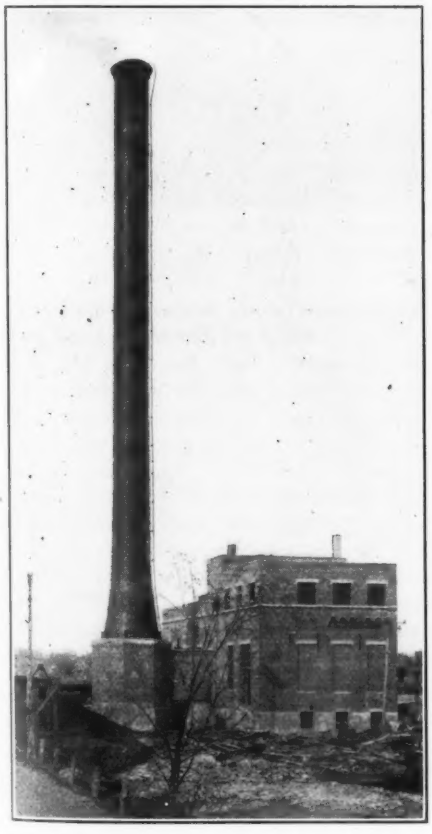


FIG. 1. POWER STATION AT EAST BRIDGEWATER

plate lined with brick. It is 10 feet in diameter and 235 feet high. The turbines and boilers are set in parallel rows, allowing for extensions in the future.

Boiler-room Equipment

At present the boiler room is equipped with three 525-horsepower Stirling boilers, with Babcock & Wilcox U-tube superheaters furnishing steam at 200 pounds pressure and 150 degrees superheat. Provision is made for two rows of boilers with a firing aisle between, and coal is brought in along this aisle on an industrial railway running the length of the coal pile. The car carrying the coal has a capacity of 1000 pounds and is pulled up the incline to the boiler room by a 10-horsepower three-phase motor geared to a winch. It is the intention to install a conveyer and a storage bin over the boiler room in the near future. Ashes drop from the grates into hoppers and are removed by means of cars.

The boilers are equipped with 4½-inch Star Brass safety valves, and the superheaters with outside-spring safety valves of the same size and make. The superheaters are connected to branches from the superheated steam main through 6-inch New Bedford nonreturn and 6-inch Chapman gate valves. The two boilers nearest the stack are connected to an

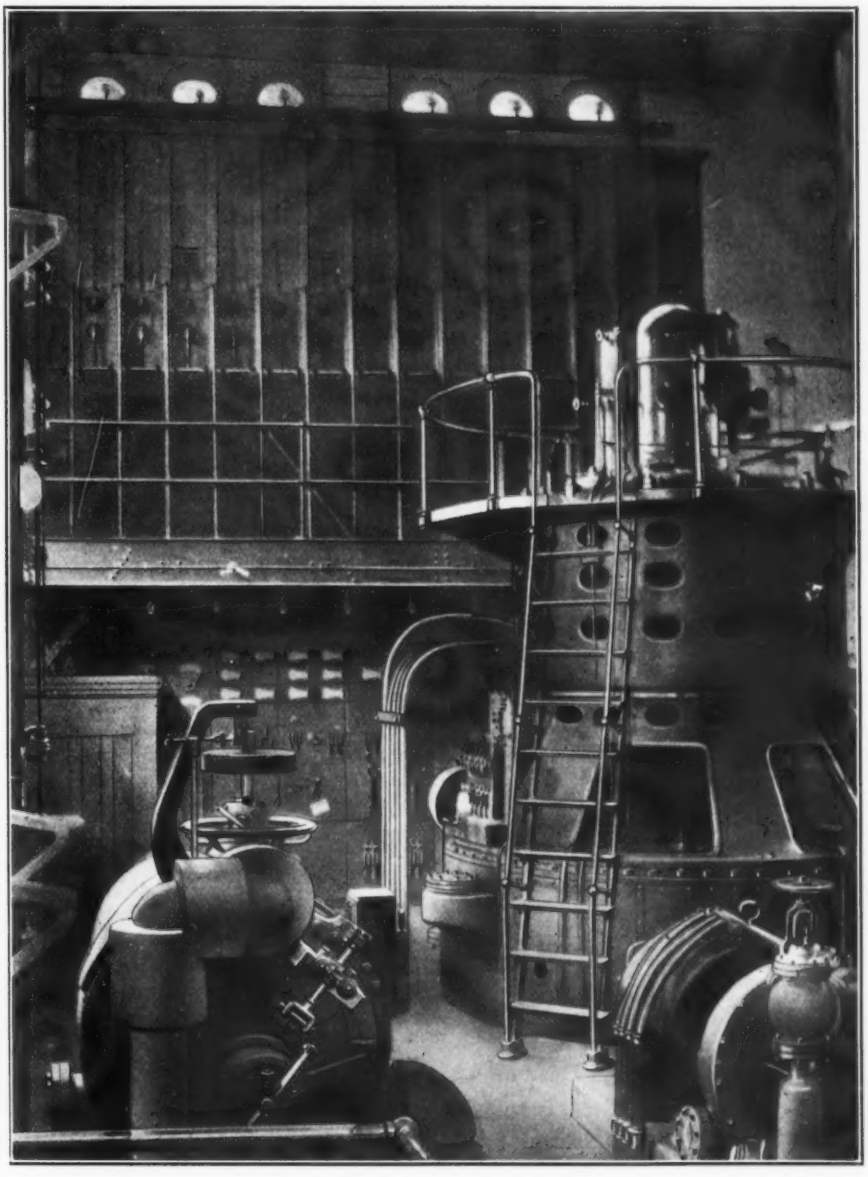


FIG. 2. EXCITERS, 1500-KILOWATT TURBINE AND SWITCHBOARD

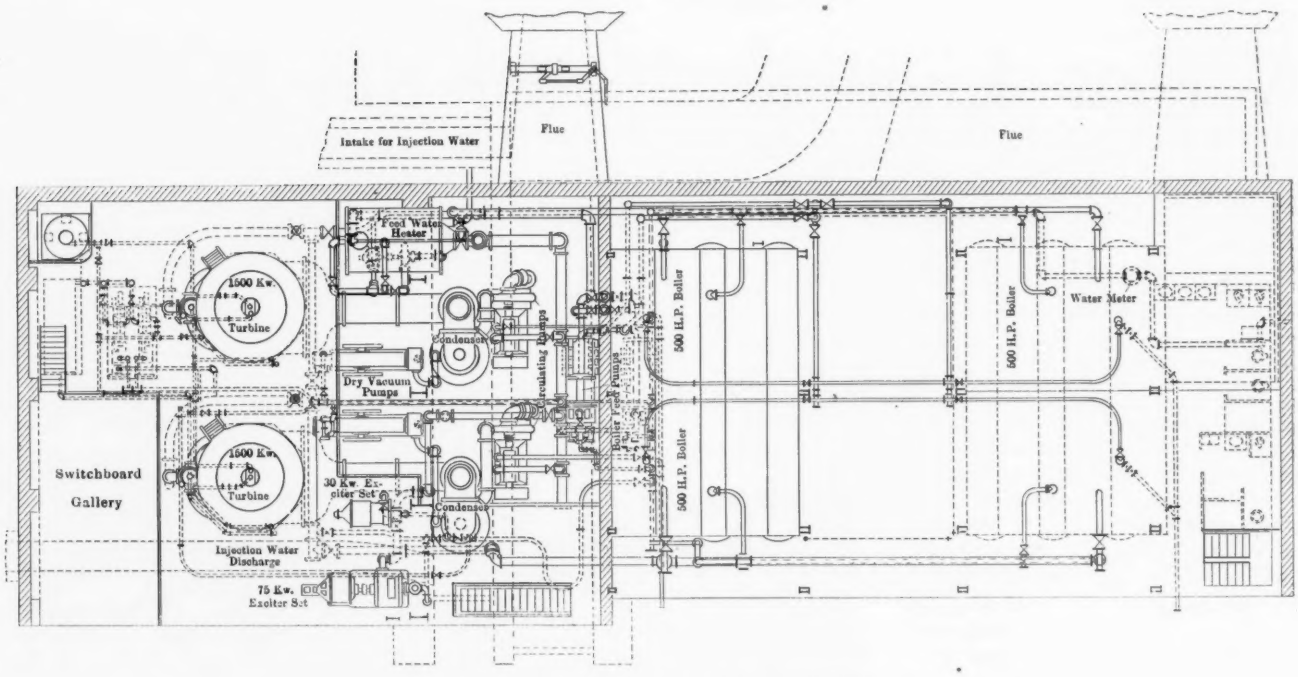


FIG. 3. PLAN OF POWER PLANT AT EAST BRIDGEWATER

8-inch branch, while the third boiler is connected to a 10-inch branch which is intended to care for four boilers. The superheated-steam main is 10 inches in diameter and is situated underneath the turbine-room floor. The saturated-steam main is also in the basement, and it is connected in the same way to the drums of the boilers. There is a connection between the superheated- and saturated-steam mains whereby superheated steam can be used on auxiliaries if necessary. The exciter turbines use superheated steam, but can be run on saturated steam if desired. All superheated-steam piping is of cast steel with welded flanges and is covered 3 inches thick with H. W. Johns-Manville 85 per cent. magnesia.

Two Blake duplex compound outside-packed plunger pumps, with cylinders 9x14x8x12-inch, take water from a Cochrane open feed-water heater and supply the boilers through two 5-inch brass mains, two ½-inch branches extending to each boiler. The feed pumps can draw water from either the cold or hot wells in case the heater is cut out, and are equipped with regulators which keep the pressure on the feed mains the same at all times.

All auxiliaries exhaust through a 12-inch main to the heater which raises the temperature of the water to 210 degrees Fahrenheit. The feed-control valves on the boilers have valve stems extending to within easy reach of the floor, and there

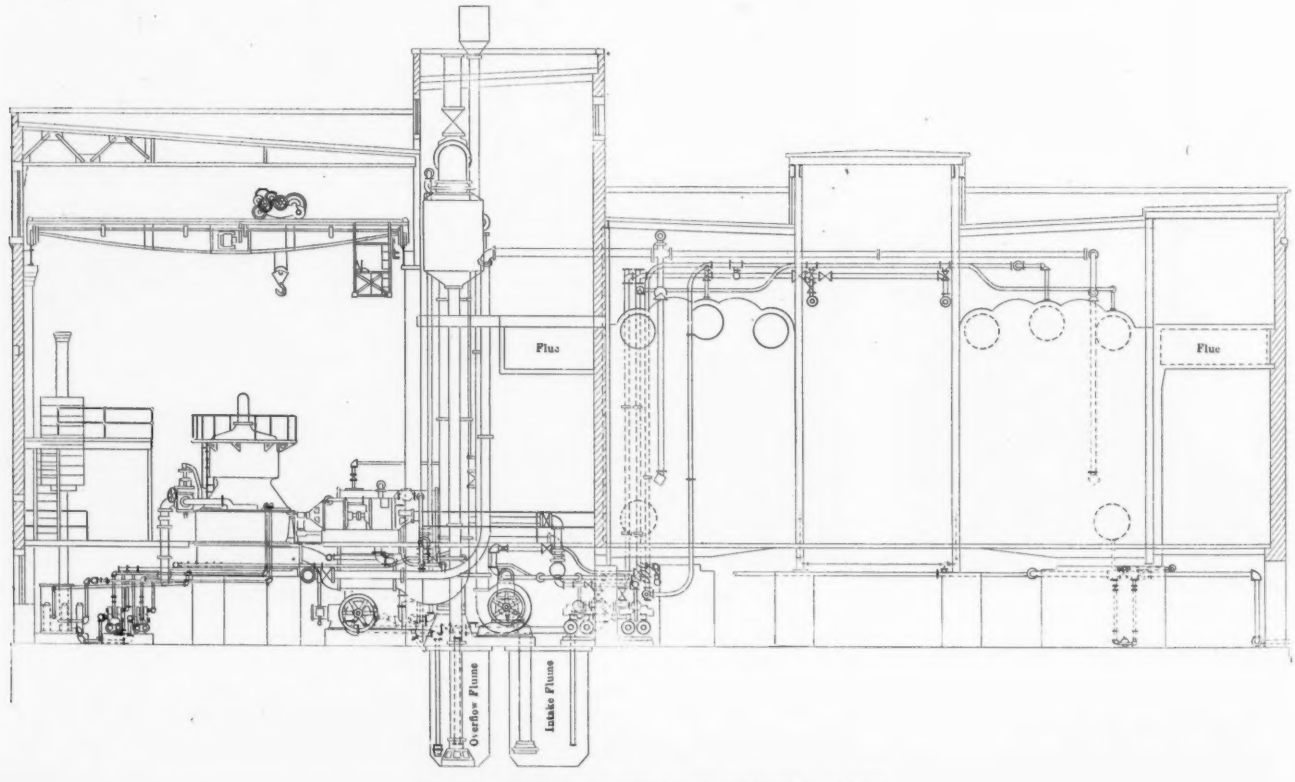


FIG. 4. SECTIONAL ELEVATION THROUGH PLANT

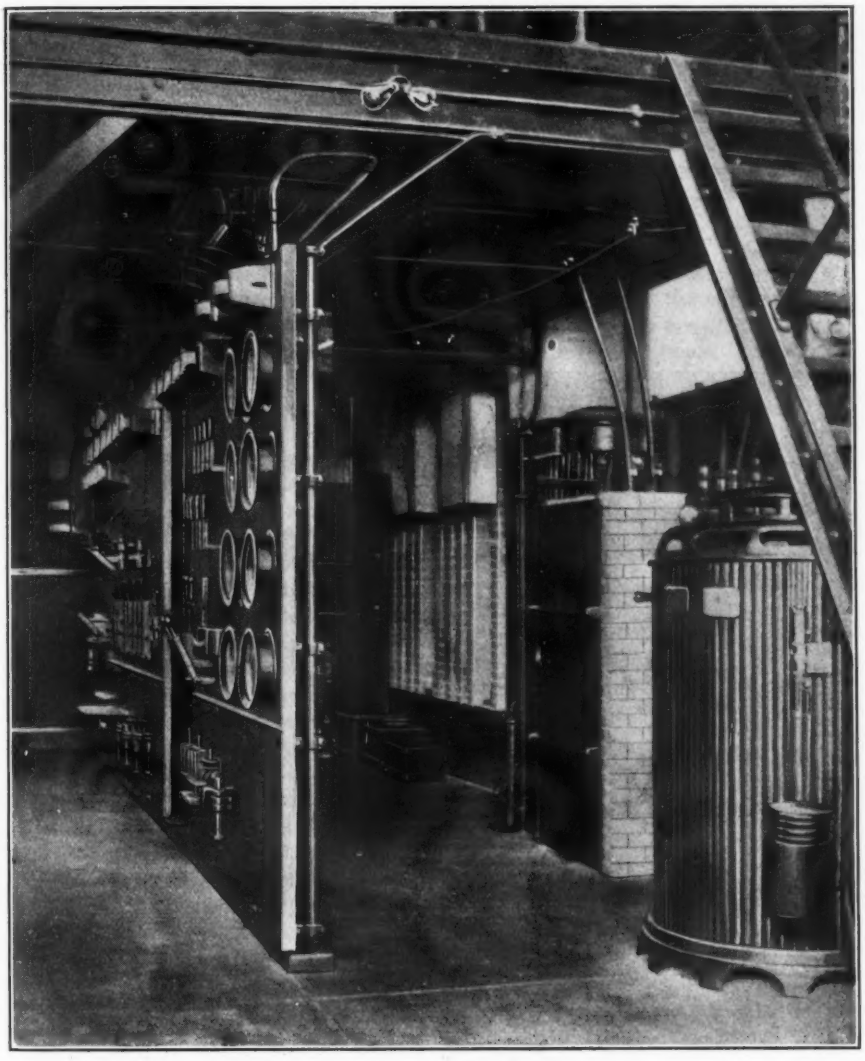


FIG. 5. SWITCHBOARD IN POWER STATION

is a stop valve and check between the regulating valve and the boiler.

A 5¼x4¾x5-inch duplex Blake service pump and tank furnish water from the cold well for all purposes about the plant, except the wash basins and shower baths in the toilet room. A 4-inch city water main is connected to all water connections and is used in cases of emergency. The hot and cold wells run parallel with the turbines and are under the basement floor, the condenser auxiliaries being grouped about them. A 4-horsepower three-phase motor, direct-connected to a Worthington volute pump, elevates the water from the hot well to the feed-water heater, a low-water alarm giving notice when the water supply to the heater fails.

Thermometers are installed in the superheated- and saturated-steam pipes, turbine exhaust, boiler flue, supply and discharge pipes of the condensers and in the feed water at the pumps and at the boilers. Readings are taken every four hours. A Venturi meter measures the amount of water fed to the boilers, and by means of a weir at the end of the discharge pipe from the condensers, the amount of water escaping can also be measured. Ellison gages show the draft pressure at the boilers. A Bristol recording steam gage is connected to the steam main and a recording thermometer of the same make keeps a record of the steam temperatures at the turbines. A Sirocco CO_2 recorder is now being installed. All high-pressure drips are returned to the boilers by a Holly steam loop.

The Turbines

There are two turbines installed and these are General Electric 1500-kilowatt four-stage condensing units running at 900 revolutions per minute. They are equipped with mechanical valve gear, and each unit exhausts through a 36-inch exhaust pipe and entrainer to a Heisler barometric condenser. Each condenser is supplied with circulating water by a 14-inch centrifugal pump driven by an 8x15x9-inch Westinghouse compound engine. The noncondensable gases are removed from the condensers by Heisler 9x20x12-inch single-stage dry-vacuum pumps. The circulating pumps are controlled by a regulator in the steam pipe, which increases the speed of the pumps if the vacuum falls. At the river the intake is protected with a 2-inch screen and at the entrance with a 1-inch and ½-inch screens. All auxiliary pumps and engines are equipped with Richardson sight-feed oil pumps.

Oil is used in the step bearings of the turbines, and a Turner oil filter and two 6x2¼x10-inch Worthington outside-packed plunger pumps are installed in the basement to furnish an oil pressure of 600 pounds, which is reduced through bafflers to 400 pounds at the bearings. An accumulator with a 10-inch plunger and 12-foot drop is connected with the oil-piping system, and will maintain the pressure on one turbine for ten minutes, in case of the failure of the pump. The oil piping is of extra-heavy brass with extra-heavy brass Chapman gate valves and cast-steel fittings. The accumulator is connected through a system of rods and levers to chronometer valves on the steam supply to the pumps, and these keep the accumulator at a fixed hight at all times. If the accumulator should start to descend, an

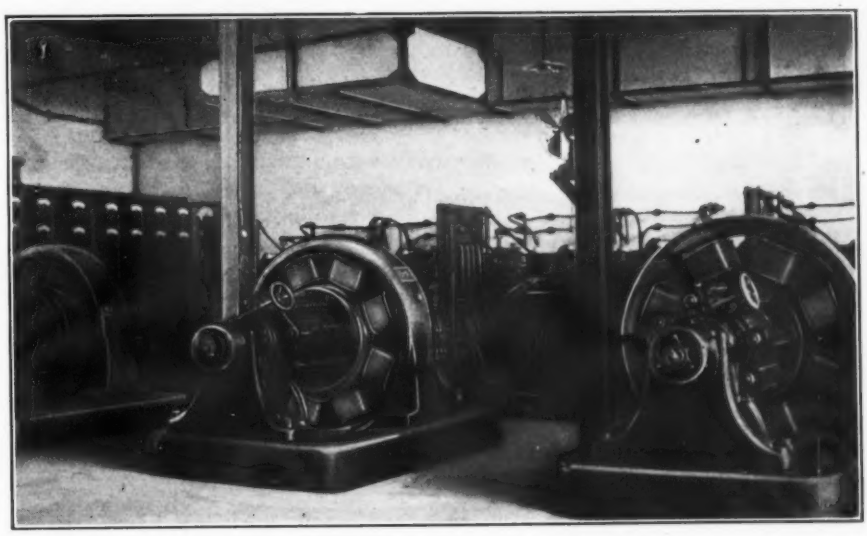


FIG. 6. ROTARY CONVERTERS IN SUBSTATION

electric alarm notifies the operator, and this alarm is tested every day when the pumps are changed.

There are two exciter turbines rated at 75 and 35 kilowatts, respectively, and these run noncondensing, the former at 2400 revolutions per minute and the latter at 3600 revolutions. A 9½x9½x10-inch Westinghouse air pump supplies compressed air for blowing out the electrical machinery, and to handle the large apparatus it contains, the station is equipped with a 20-ton Whitney electric crane.

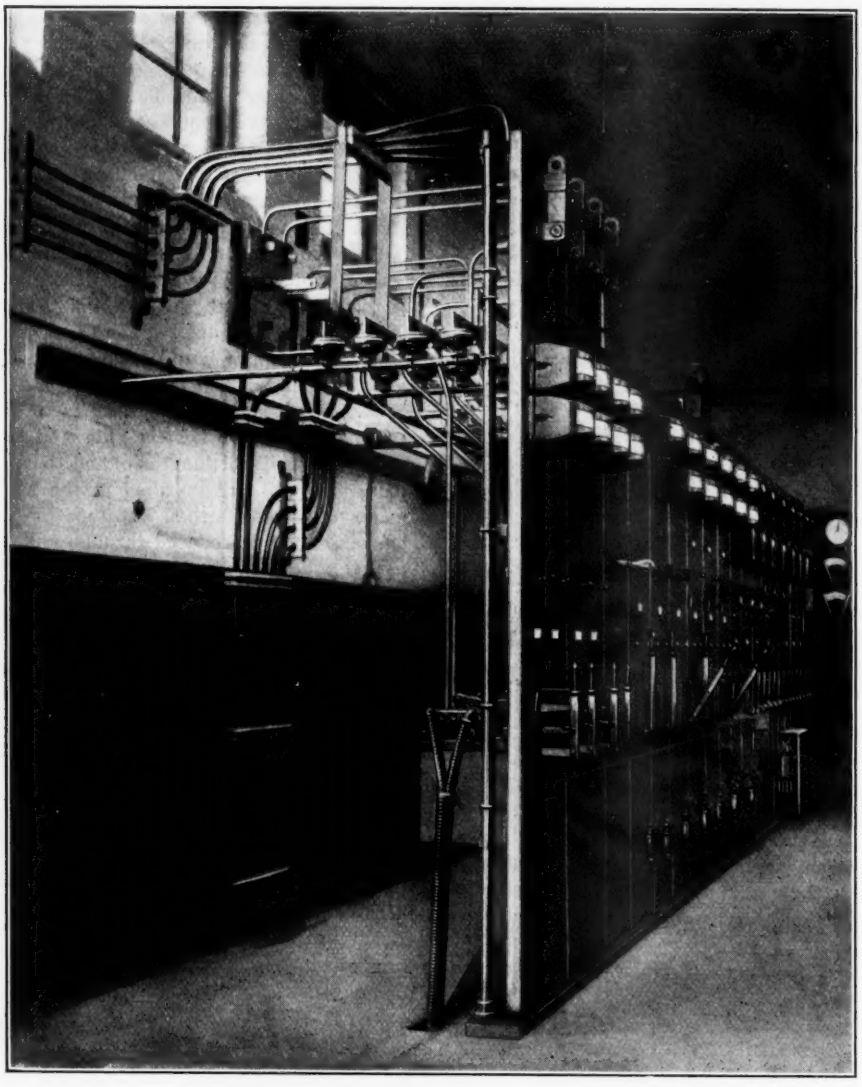


FIG. 7. SUBSTATION SWITCHBOARD

Electrical Equipment

The generators are General Electric, three-phase, revolving-field, 60-cycle, alternating-current machines with star connections and grounded neutral. The voltage is 13,200. The exciters are compound with interpole windings, and the voltage is 125 at all loads. The generator leads are run through brass conduits to the floor and then through fiber conduits to the oil switches installed in a high-tension brick structure over the switchboard. The busbars are 2x¼-inch flat copper, each bar being in a separate compartment. They communicate with the two generators through disconnecting switches and with three feeder oil switches which are mechanically controlled from the board. Each pole of the oil switches is in a separate compartment, and all potential and current transformers are also separated.

The switchboard consists of ten slate panels. One Tirrell regulator, two exciter, three feeder, one station and one local panel. Two of the feeder panels control two 13,200-volt, three-phase lines to a substation in Brockton, and the third feeder panel supplies current at 13,200 volts to transformers for the station and East Bridgewater.

Two 20-kilowatt 13,200-200-110-volt station transformers are connected to the auxiliary feeder through an oil switch and supply current for lighting the station and also to motors for the pumps and the coal hoist. East Bridgewater is supplied with current at 2200 volts, three-phase, by two 75-kilowatt 13,200-2200 transformers connected through disconnecting switches to the auxiliary feeder, and a 30-kilowatt tub transformer furnishes street lights for East Bridgewater.

On the regulator panel is mounted the Tirrell regulator with switches for use on either exciter, each exciter having two relays. Swung from this panel is a small panel carrying the synchronizer and two kilovolt meters; one is connected to the busbars and the other can be connected to any phase on either machine by means of plugs. The potential transformer for the Tirrell regulator is connected to the busbars without fuses.

Each exciter panel has an ammeter and voltmeter. One voltmeter is connected to the buses, and the other can be used on either machine. Exciter rheostats are mounted on the back of the panels and field rheostats are underneath the floor.

The generator panels have three ammeters, one indicating wattmeter, a power-factor indicator, a field ammeter and on each panel there is a switch for operating the synchronizing motor on the turbine governor. A polyphase-recording wattmeter is mounted on the back of each generator panel.

The feeder panels have one ammeter and can be connected with any phase by a jack switch. The station panel has one voltmeter and one ammeter. The voltage is 114, and the three-wire system is in use. Lighting for the plant is distributed through three panel boxes of eight circuits each. One is placed in the boiler room, one in the turbine room and one in the basement. There is one circuit for arc lamps in the yard and one for flaming-arc lamps on the ceiling. There is a double-throw, three-pole switch on this panel, whereby lighting can be thrown on the exciter in case of failure of the transformers. Another three-pole switch furnishes 220 volts, three-phase, for auxiliary motors.

The 2200-volt panel for East Bridgewater has two circuits: one 2200-volt three-phase, and the other for street lights. All feeders have automatic oil switches with time-limit relays which are tripped with current from the exciter busbars. All switchboard apparatus was furnished by the General Electric Company.

At the end of the switchboard on similar panels are the gages and speed indicators for the turbines. Each machine has a speed indicator, steam gage on the first stage, also vacuum and step pressure gages. A Holman & Maurer mercury vacuum gage is mounted on these panels and can be used on either turbine.

Brockton Substation

This is located in the business center of the city and is connected with the main station at East Bridgewater by two 88-ampere, 13,200-volt transmission lines. The lines are seven miles in length and are made up of No. 2 copper wire carried on Locke insulators. The lines run overhead from the East Bridgewater station to a lightning-arrester house, which is

situated about one-half mile from the substation, and from here are brought underground to the basement of the substation and connected to oil switches located in masonry cells remote from the switchboard panels.

At present the substation equipment comprises nine 75-kilowatt, 13,200-volt, 60-cycle, oil-cooled transformers, with one-third and two-thirds voltage starting taps for rotary converters; three 375-kilowatt, 13,200 to 2200-volt, 60-cycle, three-phase, two-phase, oil-cooled transformers, supplying the 2200-volt, two-phase service; three 220-kilowatt, 250-200-volt, direct-current, 60-cycle, six-phase, shunt-wound converters, supplying the three-wire, direct-current system; a 44,000-volt testing transformer and a 12-cell Westinghouse storage battery and motor generator charging set furnishes current to operate the trip coils on the high-tension oil switches. Located in the basement is a 2-horsepower air compressor connected by pipe line to the main floor, where the air is used for cleaning purposes.

The switchboard is constructed of the best quality of Monson slate and consists of the following panels: Two three-phase, high-tension transformer panels, one of which is spare; two three-phase incoming-line panels, three alternating-current rotary-converter panels, three direct-current rotary-converter panels and five direct-current feeder panels. Opposite each converter is located a six-phase starting panel and a Type I, right-hand, 26-kilowatt voltage regulator.

All panels are made with a ⅜-inch bevel, and the front and edges are treated with a coating of lacquer, giving a smooth, dull black marine finish. All instruments, cap nuts and handles are finished with a dull black oxide. All high-tension feeder panels are supplied with indicator lamps, red and green. The red lamps burn when conditions are normal, and green when the switch is opened by overload on short circuit, attention being immediately called to the open circuit by the ringing of a gong.

In the basement of the substation are located oil switches for controlling all high-tension lines, and these are mounted in masonry cells below the main switchboard. The entire installation, with the exception of the storage-battery equipment, was furnished by the General Electric Company.

The substation controls the current supply for Brockton, Whitman and Stoughton. Stoughton, at present, is fed by a 2200-volt line to a transformer house at Montello, a suburb of Brockton, where the voltage is stepped up to 6600, and at Stoughton stepped down to 2200 volts for distribution. In the near future Stoughton will be fed by a 13,200-volt high-tension line now under construction.

The Electric Light & Power Company, of Abington and Rockland, which lights Rockland, Abington and Hanover, is soon to be supplied from the East Bridgewater station, the high-tension line and transforming apparatus now being installed. The Stoughton, Abington and Rockland lines will tap the main feeders in a new arrester house. They will be connected to the feeders by oil switches controlled from the substation. The maximum load is now about 1600 kilowatts, but will soon be considerably increased.

Adjoining the substation is the old plant, which is held in readiness in case of emergency. Part of the feeder panels in the old station are still in use, supplied from feeders in the substation. In the old station is also located the street-lighting service, comprising a nine-panel, two-phase plug board and nine tub transformers.

Petroleum Industry of the United States

As apparent in the accompanying table, the production of crude petroleum in the United States during 1908 showed a large increase over that of 1907.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES.

(In Barrels of 42 Gal.)

Field.	1907.	1908.
California	40,085,000	45,000,000
Colorado	400,000	(a) 400,000
Gulf { Texas	12,350,000	11,904,000
Gulf { Louisiana	4,620,000	5,896,000
Illinois	24,540,024	38,000,000
Lima { Indiana / Ohio }	8,030,000	7,287,000
Mid-continental (c)	47,556,906	50,741,678
Kentucky-Tennessee	1,250,000	(a) 1,250,000
Appalachian (d)	25,500,000	24,240,000
Wyoming	13,000	(a) 13,000
Others	3,000	(a) 3,000
Total	164,347,930	184,734,678

(a) Estimated as the same as in 1907.
(c) Kansas and Oklahoma.
(d) Pennsylvania, New York, West Virginia and eastern Ohio.

California is now producing about 45,000,000 barrels of oil per year, that being the estimated output for 1908. In 1907 the yield was 40,085,000 barrels, valued at $15,908,268, or about 39 cents per barrel. In 1906 the average price was 29 cents per barrel. In 1908 the average price at the wells to the producers was about 50 cents per barrel, and at the end of the year it was perhaps higher than 60 cents per barrel. All the old contracts have been worked up, and the new ones being made vary from 50 to 63 cents per barrel. The increase in consumption of California fuel oil in 1908 was general and was from 20 to 25 per cent. over the amount in 1907, both for industrial and railroad uses, and the output is expected to keep pace with this. The Japanese are large consumers of California fuel oil and have extensive contracts mainly with companies owning wells in the Santa Maria fields. It is understood that they would take 10,000,000 barrels yearly if that quantity could be guaranteed for delivery at satisfactory prices.

Illinois produced in 1908 an approximate total of 38,000,000 barrels of oil. The price remained fixed at 68 cents per barrel for all oil above 30 degrees Beaume and 60 cents per barrel for that below 30 degrees Beaume. The great bulk of the oil, however, was marketed at the higher rate.

The 1908 estimates for Texas are 11,904,000 barrels, of which about 10,010,400 barrels are credited to the coastal region. The Louisiana output is placed at 5,896,000 barrels, making the total for the coastal field 16,000,000 barrels. The selling prices of crude oil varied greatly and was so much lower than in 1907 that the total value declined from $14,000,000 in that year to about $10,500,000 in 1908, the price per barrel ranging all the way from 75 cents down to 38 cents. It is unlikely that the Texas-Louisiana production will decline materially in 1909, for while the oilfields are failing they are still capable of development and will be actively worked.

In the Mid-continental field, meaning Kansas and Oklahoma, no change whatever occurred in the prices of crude oil throughout the year. Oil at 32 degrees Beaume or lighter brought 41 cents regularly.

In the Appalachian field, including Pennsylvania, New York, West Virginia and eastern Ohio, the total production of petroleum has been steadily declining for years. In 1908 there was a farther decrease in the production; that is, 24,240,000 barrels, as compared with 25,500,000 barrels in 1907, 27,345,000 barrels in 1906, and 28,324,324 barrels in 1905. West Virginia is the only district in the Appalachian field that holds out any great possibilities of increasing the supply of high-grade petroleum, for in the southwestern part of the State there is a large unprospected area. The price during 1908 stayed at $1.78 per barrel throughout the year.

In the Lima oilfield, that is, the oldfields of northwestern Ohio and northeastern Indiana, there was a falling off in petroleum production. The total production in 1908 being 7,287,000 barrels, as compared with 8,030,000 barrels in 1907. The average price paid for north Lima was $1.03 per barrel, as compared with 93½ cents in 1907, and for south Lima 98 cents as compared with 88½ cents in 1907.—*The Engineering and Mining Journal.*

A correspondent contributes the following rule for finding the cubical contents, in gallons, of a cylindrical tank: Multiply the square of the diameter in feet by half the length in inches. The result is about 3 per cent. too low, but is close enough for ordinary purposes.

It is stated that the highest generator voltage in use is that at a hydroelectric plant at Manojlova falls on the Kerka river in the province of Dalmatia, Austria-Hungary, which generates electric current at 30,000 volts. This is fed direct to the line without the use of step-up transformers and transmitted 21 miles.

Gate Valves in Steam-Pipe Lines

Practical Suggestions for Locating and Using Them in These Days of Saturated Steam at High Pressure and Superheated Steam

BY W. H. WAKEMAN

The use of saturated steam at high pressure, and superheated steam at any pressure, has rendered obsolete some of the globe valves that formerly did good service in our main steam lines, therefore others must be substituted. However, the fact that certain hard-rubber, or composition, disks are quickly destroyed by steam at high temperature does not necessarily condemn all kinds of globe valve, even for severe conditions, while for ordinary plants the composition disk is as good now as it was twenty years ago. In view of these facts the use of gate valves in steam-pipe lines is uncalled for, and furthermore it is not an intelligent application of knowledge along this line, because a gate valve is always more difficult to operate and more expensive to repair than a globe valve. There are gate valves that contain composition disks, so may easily be replaced when worn out, making the valve as good as new, provided the seat is not injured; but if the seat requires repairs it is a hard and expensive job to scrape the surface until it becomes perfectly true.

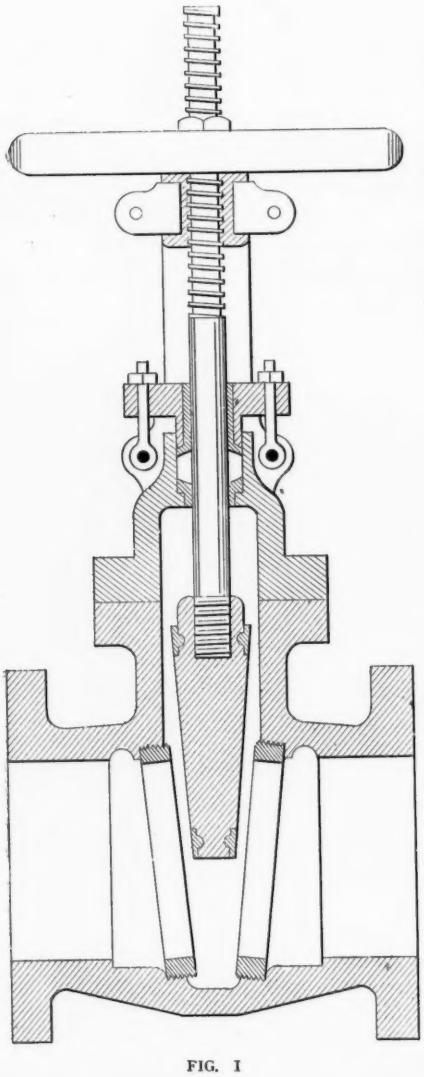


FIG. 1

There is more than one way to locate and use a gate valve, and as they are not all made alike, suggestions along this line should prove valuable.

If a valve of this kind is located with the stem in a vertical position, as shown in Fig. 1, friction is reduced to a minimum, because the heavy gate is suspended on the stem, the surfaces in contact being small in consequence. The only objection to this arrangement, as far as the valve itself is concerned, is that a pocket which is formed at the bottom between the two inclined seats is located just right to catch sediment and scale, and thus prevent the gate from going down to its proper place, but fortunately there is little danger of an excessive amount of sediment collecting in a steam-pipe line.

This valve is fitted with what is technically known as a rising stem, because the wheel stays in the same place (except that it revolves) when the valve is operated, while the stem travels with the gate. This point must be taken into consideration when locating a large valve in close quarters. A left-hand thread must be cut on the stem in order to cause the wheel to operate in the correct way, which is to turn with the hands of a watch to close the valve, and in the opposite direction to open it.

Fig. 2 is fitted with a nonrising stem, consequently the space occupied by the valve is a fixed quantity at all times. This must also be a left-hand thread. It is concealed in the bonnet and the gate, and cannot be lubricated properly, which causes it to wear much more rapidly than if it were exposed and well oiled. The collar shown on the stem soon wears enough to give objectionable lost motion, as it cannot be oiled.

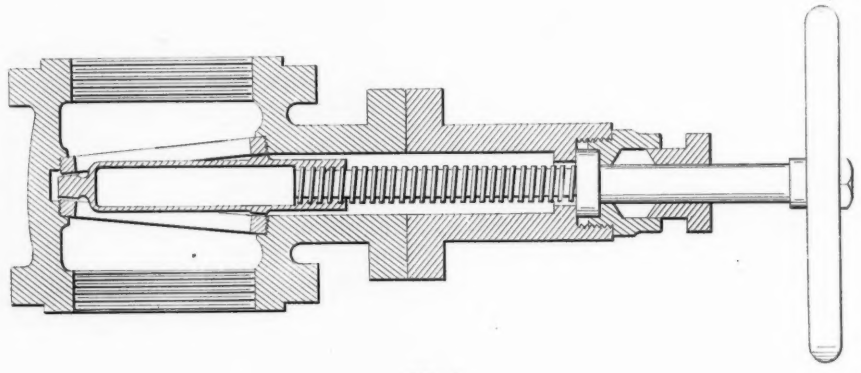


FIG. 2

A valve of this kind is located in an 8-inch horizontal branch steam line in my plant, and the stem is in a horizontal position. The consequence is that when this valve is opened and closed, the gate must slide on its edge, traveling on a rough guide, and the resulting friction causes grunts and groans that are very disagreeable because they denote inferior design and imperfect workmanship, although the name of one of the best known construction companies in New England is cast on the bonnet.

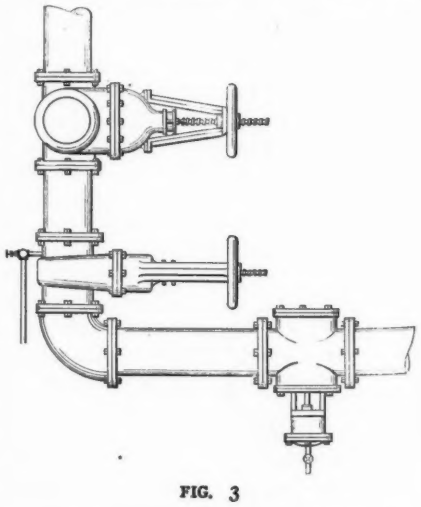


FIG. 3

This branch line was designed to supply steam for two engines, only one of which is in use at present during a part of the time; and after that engine is shut down it seems proper to close the gate valve mentioned, as it is located near the header, which extends across five boilers, and much heat would otherwise be lost. The ordinary plan for doing this is to close the throttle valve and, after the engine has stopped, to shut the gate valve, then allow steam in the pipe to condense, as a good trap removes all water resulting from the cooling process. If this plan is followed here the gate valve leaks badly and heat is wasted the same as if it was left open. This is due to the fact that when the gate chatters over the rough

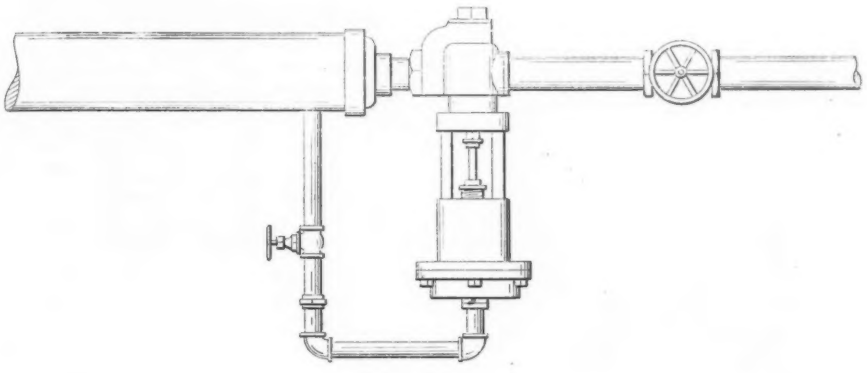


FIG. 4

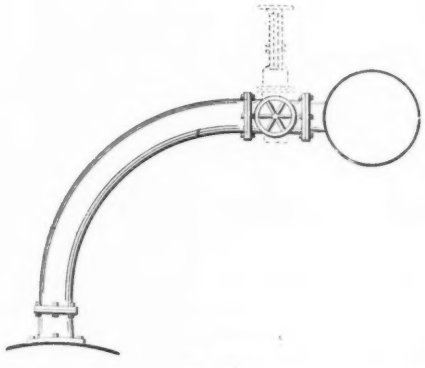


FIG. 5

guide mentioned it is in equilibrium, consequently it is not held against the seat. The threaded stem is a very loose fit in the gate; therefore, when the latter is forced as far as it will go, it does not rest squarely on the seat, and it leaks.

This action is proved by the following result: If the gate valve is closed while the engine is running full speed, the gate is not in equilibrium, as pressure is reduced on the engine side; therefore, the gate is pressed firmly against the seat and when the valve is closed it is perfectly tight. After the engine has stopped the throttle valve is closed.

The upper valve in Fig. 3 (which represents a section of piping in my engine room) is represented as being located in a horizontal line coming directly toward the reader. It is fitted with a rising stem, or outside thread and yoke. The valve below it is quite differently located, for although its stem is in a horizontal position, the body is in a vertical pipe. In this case the gate always rests on the seat, giving smooth action in opening and closing, and a tight valve when shut. Both sides of the gate are intended to be steam-tight.

One advantage of a gate valve in this service is that if the wheel is turned with ordinary speed, which is always slow in good practice when the valve is to be opened, the opening for the admission of steam will be very small at first and will increase slowly, thus giving time for pressure to rise gradually, and avoiding the shocks and jars caused by turning too much steam into a comparatively cool pipe. It is difficult, but not impossible to secure the same result with a globe valve, because a similar movement of the wheel gives so much greater opening for the passage of steam. This type of valve has several advantages, but this is not one of them.

It follows as a natural consequence that it takes a comparatively long time to open a gate valve, which is an annoying feature when haste is necessary. I have noticed, however, that some engineers take more time than is necessary under conditions shown in Fig. 3. The small angle valve connected above the gate is first opened to draw off the water of condensation, then the larger one is slowly opened, admitting steam to the reducing valve in the horizontal pipe below it. Soon a light pressure accumulates and brings the reducing valve into action. As soon as this is evident, the large valve may be opened quickly. It is not necessary to continue the slow process until the long stem is run out to its full length.

Globe Valve Substituted for a Gate Valve

Fig. 4 illustrates a section of piping where a globe valve was substituted for a gate valve, to my great satisfaction. Formerly it was necessary to exert a considerable force to start the gate (as there was no bypass provided), then it required nearly two revolutions of the wheel to open the valve slightly, and when the reducing valve began to operate the gate moved easily because the pressure was balanced; but it took about six revolutions more to secure a full opening. With the globe valve in use, the instant that the wheel is moved steam begins to pass through, and after the reducing valve begins to control the pressure in the system, requiring but a few seconds for the operation, about two revolutions of the wheel opens the valve to its full capacity. When steam is to be shut off there is practically no friction to be overcome because the disk is in equilibrium until it

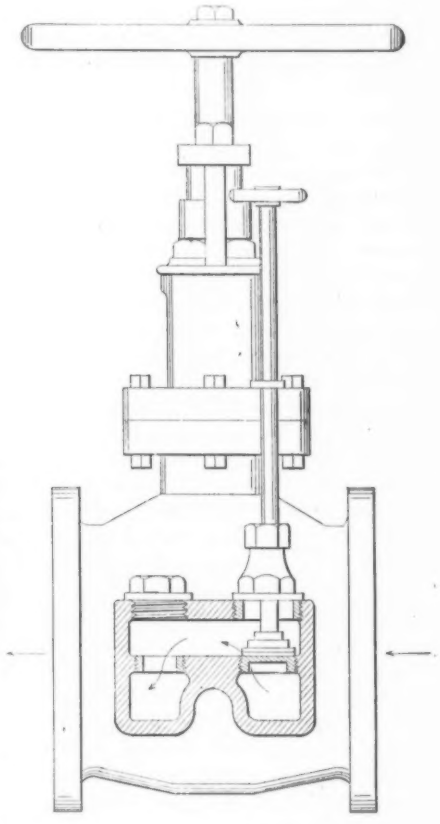


FIG. 6

rests on the seat. The contrast between this and operating the gate valve which was used in this place for twelve years is very great.

Fig. 5 illustrates a connection between one of my boilers and the header which receives steam from all of them. A gate valve is used here with its stem in a horizontal position. When this boiler is to be "cut out" the valve is shut in the usual way, but the disk is always balanced, or in equilibrium, and this condition is never changed, because pressure cannot be reduced on one side of it. The result is that when the boiler is cooled off and the manhole cover removed, steam may leak in or it may not, according to the position which the disk took when forced to th-

limit of its travel. If it was practicable to lower the pressure on one side of it, the result would be more satisfactory, as explained in connection with Fig. 2. If the stem of this valve was located in a vertical position, as represented by the dotted lines, it would undoubtedly give better results. However, there is not head room enough for this purpose, especially for a rising stem. A globe valve with a pin, projecting from the lower side of the disk, that travels in a guide provided for this purpose would be much better.

Fig. 6 is a gate valve fitted with a bypass, the operation of which is apparently not as well understood by firemen and engine runners as it ought to be. Steam enters as indicated by the arrow and, acting on one side of the closed gate, presses it to its seat with great force; therefore, it is necessary to overcome excessive friction before the valve can be opened, especially with steam at very high pressure. To overcome this objection the bypass is provided. By opening the small globe valve which is cast with the body of the large valve, steam is admitted from the right-hand side of the gate around it to the left-hand side, as shown by the arrows. This fills the space at this point and raises the pressure until the gate is balanced and nearly all friction removed; consequently, the valve can easily be opened, after which the bypass is shut. When a man closes the bypass before he opens the main valve, thus reducing the pressure on the outlet side, it is good evidence that he does not understand the value of a bypass. If this device is wanted in a case where it was not included in the original valve, it can be provided by tapping a small pipe into the main line on each side of the large valve and putting a small valve in it.

As a general rule a gate valve is designed so that it is not convenient to get bolts into the flange on the bonnet, as the space allowed for this purpose is too small, making it necessary to drop some of the nuts down behind the flange and screw the bolts into them. Bolts that are carried in stock by supply houses have heads that are supposed to be artistic in design, but when a wrench is applied to them it is sure to slip off, to the disgust of the workman who wishes to do a good job. To overcome this objection I have found it a good plan to take round norway iron and cut it into suitable lengths to go through the flanges and two nuts, then by cutting a thread on each end and tapping nuts to match, it is possible to make studs to be used as bolts that can be applied to good advantage, and a proper wrench will not slip off, especially if square nuts are adopted. There are a few places in a steam plant where square nuts cannot be turned, but they are much fewer than is generally admitted, judging by the large proportion of hexagon nuts used, which soon become almost round if a wrench is applied to them a few times; consequently, they are not screwed down tight enough to prevent packing from blowing out under pressure. This applies to the quality of nuts usually found on the bonnets of gate valves and ordinary flange joints.

The James Watt Memorial Building

By W. H. Booth

Greenock is a small town down the Clyde a few miles below the city of Glasgow. Its occupation is chiefly shipbuilding, and its title to fame historically rests on the fact that James Watt was born there in the year 1736 on the nineteenth day of January. James Watt, by his invention of the air pump and separate condenser, laid the foundation of modern practice in steam engineering. It was the first stage in the compound working of the steam engine and marked the abolition of the practice of doing two operations in one vessel, for in the Newcomen engine the cylinder was alternately a jet condenser and a working steam cylinder. We deplore today the initial condensation which takes place in a cylinder that has been merely momentarily exposed to the condenser pressure and temperature, but what must it have been when the cylinder was drenched with cold water?

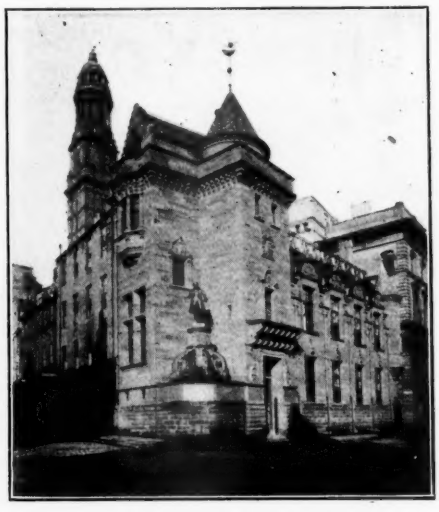


FIG. 1. JAMES WATT MEMORIAL BUILDING

The story goes that Watt, who was mathematical-instrument maker to the Glasgow university, had intrusted to him a model of a Newcomen engine to repair. Being a man of scientific bent of mind and specially trained in a trade that would cultivate his thinking faculties, he naturally would begin to think about the steam engine. He came of a family of some local standing in Greenock, for his father was a maker of ship blocks and was a member of the local council and a magistrate; his grandfather was a teacher of surveying and navigation, and his uncle was a surveyor and civil engineer at Ayr. The story of his youth about the tea kettle appears to have been invented as a bit of telling biography. If he had really thought so early about the steam engine, he would have done something with it earlier than he did.

Watt was delicate in health and had little scholastic training. At the age of eighteen he was sent to London to learn the trade of instrument maker. There he stayed only a year on account of bad health. Returning to Greenock he set up in business in Glasgow as a mathematical-instrument maker, and the university authorities, perhaps through influence, gave him a helping hand and appointed him instrument maker to the university, with rooms in the building. He did not make very much at his trade and eked out his small income by mending and even making fiddles.

This would bring us to about the year 1756. Watt apparently spent some ten years at the university, and in 1767 was employed to make a survey and estimate for a canal to unite the Clyde with the estuary of the Forth. After this he obtained more civil engineering work and was engaged in work in connection with the deepening of the Clyde and other rivers, with harbor work and canals.

It was in 1759, however, that Watt began to study steam, and for some years he made experiments on that critical and elusive fluid. He would then be about 23 years of age. It was about 1763-4 that the Newcomen model fell into his hands for repair, and in 1769, when 33 years of age, he took out his patent in which he says:

"My method of lessening the consumption of steam, and consequently fuel, in fire engines, consists of the following principles:

"First—That vessel on which the powers of steam are to be employed to work the engine, which is called the cylinder in common fire engines, and which I call the steam vessel, must, during the whole time the engine is at work, be kept as hot as the steam that enters it; first, by inclosing it in a case of wood; secondly, by surrounding it with steam or other heated bodies and, thirdly, by suffering neither water nor any other substance colder than the steam to enter or touch it during that time.

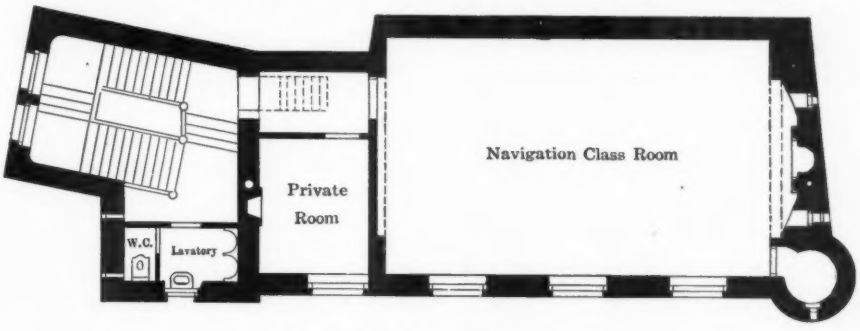
"Secondly—In engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the steam vessels or cylinders, although occasionally communicating with them; these vessels I call condensers; and while the engines are working, these condensers ought at least to be kept as cold as the air in the neighborhood of the engines, by application of water or other cold bodies.

"Thirdly—Whatever air or other elastic vapor is not condensed by the cold of the condenser, and may impede the working

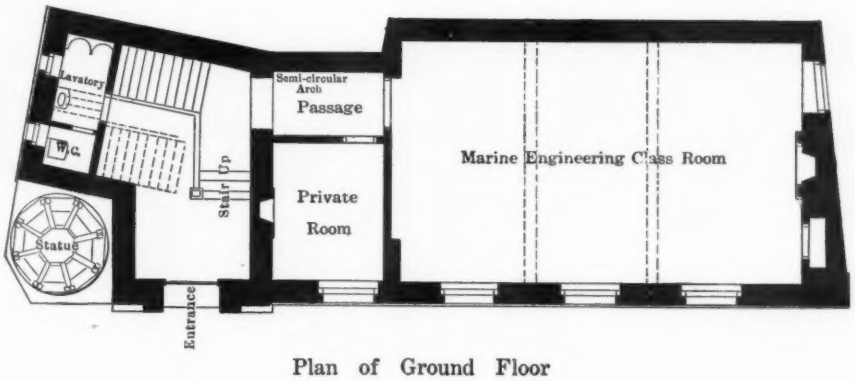
of the engine, is to be drawn out of the steam vessels or condensers by means of pumps, wrought by the engines themselves or otherwise.

"Fourthly—I intend in many cases to employ the expansive force of steam to press on the pistons, or whatever may be used instead of them, in the same manner in which the pressure of the atmosphere is now employed in common fire engines. In cases where cold water cannot be had in plenty, the engines may be wrought by this force of steam only, by discharging the steam into the air after it has done its office.

"Lastly—Instead of using water to render the pistons and other parts of the engines air- and steam-tight, I employ oils,



Plan of Upper Floor



Plan of Ground Floor

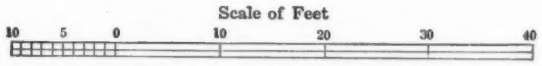


FIG. 2. FLOOR PLANS OF BUILDING

hose, resinous bodies, fat of animals, quicksilver and other metals in their fluid state."

Here is the whole art of steam engineering as we have, one might say, half forgotten it today, for to read some of the denials of the well known effect of cylinders in condensing the steam, or much of it that enters them, one might almost wonder if the separate condenser was not a superfluity.

Dr. John Roebuck was the first to extend financial aid to Watt. He was the original proprietor of the Carron Iron Works, where carronades were first cast, and many of the productions of the Carron company may be seen today on the ramparts of Quebec, bearing on their trunnion ends the words Carron and the dates 1905, 1906, 1907.

Presumably Dr. Roebuck tired of the expense or did not appreciate the value of the invention or perhaps he found the cost greater than he could afford, for we next find Watt being liberally helped by Matthew Boulton, a Birmingham man. To Boulton, of Birmingham, the world owes it that Watt's great invention was put into successful operation. Watt's patent was much contested, but Boulton found the necessary fighting funds which enabled Watt to establish the validity of his patents. Watt invented a cutoff in 1769 and described it in a letter to Dr. Small. He used the cutoff in 1776, but did not patent it until 1782, when he patented it and the double-acting engine with the rod parallel motion in place of the link chain and quadrant-ended beam, as seen in the old engines at South Kensington Museum. As someone else had patented the crank, Watt had to invent the sun-and-planet gear to take its place. It is claimed that Watt had invented the application of the crank before 1778, but that some other man had patented it. Practically, Watt left the steam engine as it is today. Nothing has yet gone beyond his enunciated principles.

His native town of Greenock has long wished to have some memorial of Watt, but so far as Scotland is concerned Watt's monument has been like Wren's "Circumspice," for the river Clyde as it now is is the direct result of the great vessels which are built on its banks and driven by Watt engines. The Watt Memorial House is, therefore, about one-tenth general public and nine-tenths Dr. Carnegie, for only about $5000 was generally subscribed until Andrew Carnegie subscribed $50,000 in two instalments, and later a subscription, limited to 25 cents, raised a further sum of something between $1500 and $2000 under the care of an engineer, John Rankin, of Greenock. The scheme, as carried out, is by no means so ambitious as originally intended, owing to the small response that the public made. Ultimately it took the form of a small technical institution costing something over $35,000, the remainder of the fund, about $20,000 serving as an endowment and for furnishing, so that not more than $15,000 has been really available by way of endowment.

The memorial building stands at the corner of William and Dalrymple streets, on the site of the house in which Watt was born. It is only two stories high and at the corner about 10 feet from the ground the building is constructed with a reëntrant square corner, leaving a square platform at that hight of about 10 feet, on which stands a pedestal surmounted by a statue of Watt, 8 feet 6 inches high and cast in bronze from the modeling of Henry C. Fehr, of London, and a replica of a similar statue already at Leeds. The base of the house is rough-faced granite to a hight of about 7 feet, above which the walls are of dressed stone. Within are two class rooms, 40x24 feet, for the teaching of navigation and marine engineering. It is hoped these will be found of service to officers desirous of passing their examinations when in port. The roof is flat, so as to serve as a deck whence to take solar observations, for even at Greenock the sun is sometimes very much in evidence.

In the engineering class room are drawing benches with lockers and models, many of which have been given to the institution, and there are some 300 volumes in the little library on engineering and navigation. The room is oak-paneled to a hight of 8 feet. A fireplace of Giffnock stone is in the Scottish baronial style. This room is on the ground floor. On the first floor is the navigation room similarly equipped and fitted and with Cymric ornamental ceiling. The building was opened on Monday, June 1, 1908, and Watt's statue was unveiled by Dr. Carnegie. The inscription on the marble plinth reads:

James Watt
Born 1736—Died 1819.
This Memorial Building is Erected on the Site of His Birthplace.

The outer door opens on Dalrymple

street and is made of teak. Above the door is the Greenock coat of arms with the inscription:

Sigillum Burgi de Greenock.

The electric-light fittings are of hand-wrought iron with armorplate finish, and there is provision for special lighting for demonstration purposes. The supply comes from the corporation mains, the switch-board being in the entrance hall.

The architect to whom the work was intrusted was David Barclay, of 245 St. Vincent street, Glasgow, and to him we are indebted for the plans of the building. Since the building was to represent a house that formerly stood on the site, though not intended to be a copy of the old house, it was decided that to some extent it should represent a style of Scottish architecture.

The primary object of the building was to mark the site of the house in which James Watt was born, and the memorial house is itself small since it is confined to the site of the original house which it memorializes. The locality is near to the harbor, for one old tenement house alone intervenes. This it is generally desired should some day be removed should there be funds available for the purpose. If so, the view of the memorial house would be opened up to the river. As in all industrial and growing towns some localities become reduced in character, so has this. It has suffered very considerable decadence since the Watts lived on the site and a general demolition of some of the neighboring properties would be a worthy public improvement if the finances of the town would permit or the public generally would interest themselves in the matter and step in to finish the work inaugurated by Dr. Carnegie.

The architects prepared, we are given to understand, several designs for a memorial, and of these one at least was purely memorial, but Dr. Carnegie expressed a desire that there should be some building that should serve a useful purpose as well as being an ornament, and therefore the final choice fell on the design as carried out. Since the building was to be so small, too much was not attempted, and the teaching to be given within it was narrowed down to the subjects named, marine engineering and navigation, each of which is allotted one of the large rooms.

FIG. 3. ENGINEERING CLASS ROOM

FIG. 4. NAVIGATION CLASS ROOM

In accordance with the object of the building, the finishing of the rooms is perhaps more elaborate than usual with class rooms, the walls being paneled in timber and the mantelpieces being of carved stone, but the wall paneling is so designed as to serve for blackboard purposes and the exhibition of diagrams. The upper floor ceiling is vaulted and decorated with Cymric ornaments, while the small rooms of the staircase tower will serve for museum purposes. The stone carving records ancient and modern engineering and shipbuilding. The statue itself is in the dress of 100 years ago, and Watt appears to be reading a steam gage. The pedestal is supported by flying buttresses of antique design carved with some elaboration with emblems of engineering tools.

Seeing that the site was so small, the house appears to have been designed to fill a useful purpose about as well as could be, and the purpose it will fill is closely connected with the trade and industry of the town. It might be pointed out that the Clyde, down which have been launched some of the largest ships ever built, was once a mere shallow creek, and but for the steam engine and all that the steam engine has rendered possible, it would have remained so. Watt's invention set the steam engine along the road of improvement and started the struggle for coal economy which has today culminated at or near the long-sought one pound per horsepower per hour. But today, though we possess the turbine and the surface condenser and accurate machine tools, we are still striving after Watt's axiom, the keeping of the cylin-

Modern British High-Speed Steam Engines

Design of the Type of Governor in Most General Use; System of Forced Lubrication; Some Makes of High-speed Engines

BY JOHN DAVIDSON

Governors

As previously stated, in all cases the engines are governed by means of a centrifugal governor attached to the crankshaft, which controls the speed of the engine by acting directly upon a throttle valve of a balanced type. Where the load of the engine is nearly uniform this system of governing leaves nothing to be desired, either in speed regulation or economy. The type of governor used by almost all firms is practically the same, and the general design is illustrated in Fig. 10.

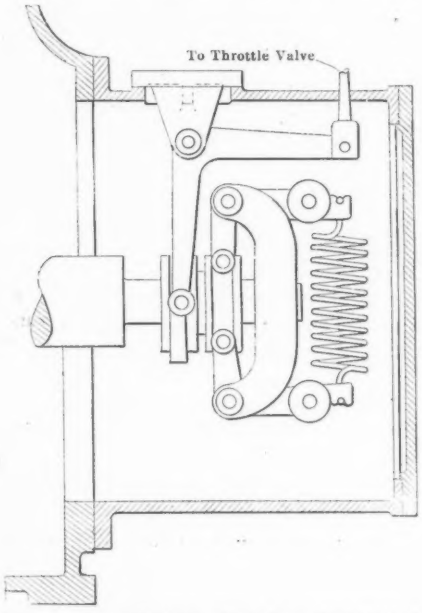


FIG. 10. A COMMON TYPE OF CENTRIFUGAL SHAFT GOVERNOR

In connection with this governor it is general to supply a speeder gear by which it is possible to vary the speed of the engine at least 5 per cent. above or below normal, while the engine is running. This is generally effected by means of an additional spring attached to the speeder rod or bell-crank lever of the governor, in such a way that it may act with the main governor spring, so that if the tension of this spring is varied the speed of the engine will be varied accordingly.

Recently the governor gear has been put under forced lubrication, so that no part of the engine requires attention, all being lubricated from the main oil pump. The throttle consists of a single double-beat Cornish valve designed in such a way that it is not affected by difference in temperature. In Fig. 11 is shown a section of this valve.

The throttle-valve spindle is made steam-tight where it leaves the valve box by simply being passed through a long bushing, inside of which are turned several water grooves. This method of packing the spindle has been found much more satisfactory than fitting stuffing boxes of the ordinary type, as it is most essential to guard against friction in any part of the governor gear, and where stuffing boxes are introduced it is easy for the attendant to upset the governor and cause hunting by simply screwing up the gland.

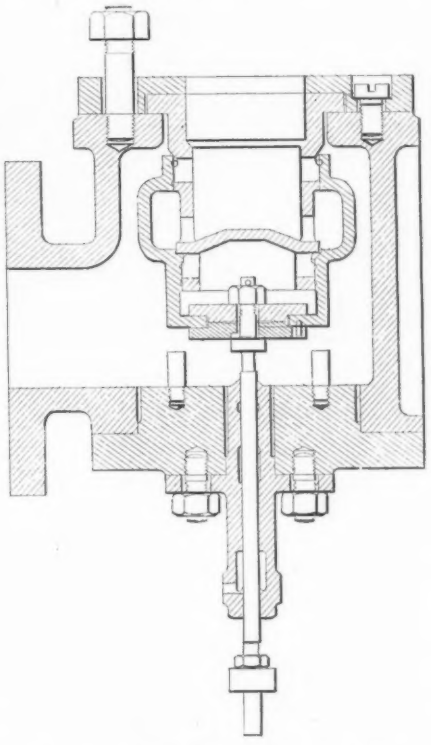


FIG. 11. DOUBLE-BEAT CORNISH THROTTLE VALVE

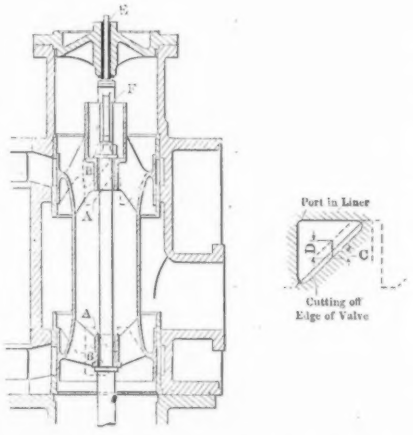


FIG. 12. METHOD OF VARYING CUTOFF

During the last two or three years, governing by means of varying the expansion has again been taken up, but this time has only been combined with throttle governing. Great trouble was previously experienced from crankshaft governors acting directly upon the eccentric driving the valve. In the later type of expansion gear the degree of expansion is altered without varying the travel of the valve, and simply by rotating the main distributing valve on its spindle through a small angle. The valve can easily be actuated in this manner by the governor, as the inertia of the valve gear has not to be overcome. In Fig. 12 is shown one method of carrying out this arrangement. The centrifugal governor acts on the throttle valve in the usual way. From no load up to 75 per cent. load the engine is entirely under control and governed only by the throttle valve. As the load increases, the throttle-valve spindle is opened farther by the governor, but in doing this, by means of levers and an upright shaft, the main piston valve is caused to rotate through a small amount by means of the spindle *E* which carries a fork *F* engaging with recesses as shown on the extended portion of the piston valve. The edges of the piston valve are cut at an angle, as shown

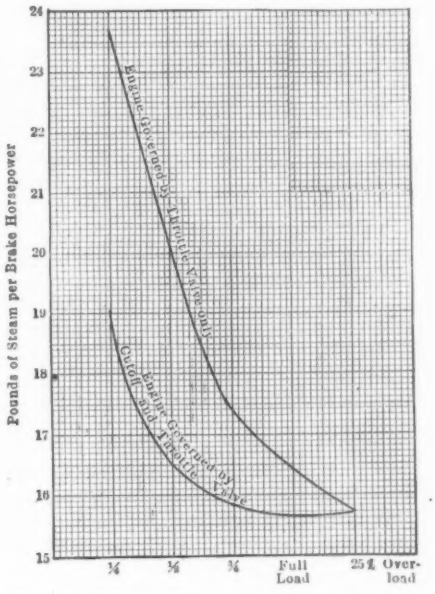
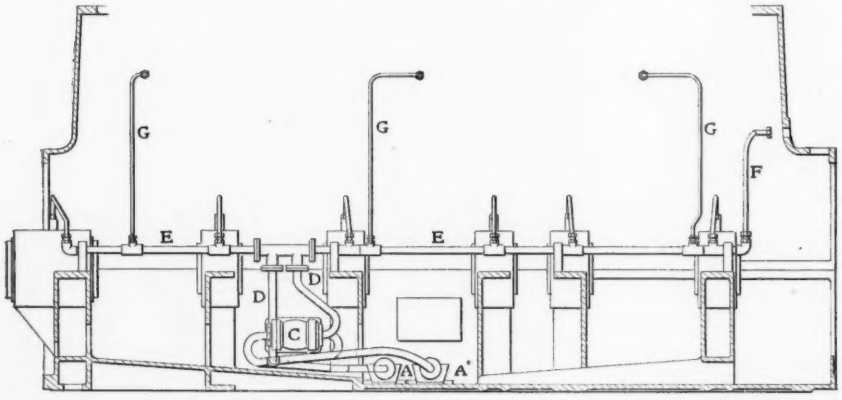


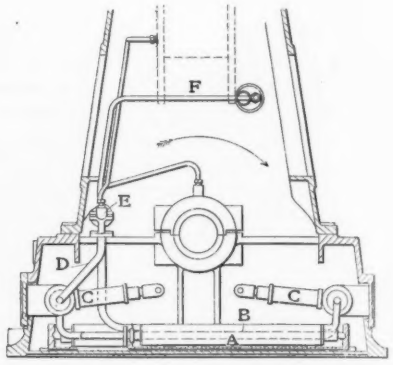
FIG. 13. ECONOMY OF VARIABLE EXPANSION

at *A*, and the ports in the liner are made in triangular shape, as shown at *B*.

In the drawing at the right is shown to a large scale one of the ports and the edge of the valve, and the corresponding edge of the valve when at the earliest cutoff position. The lead of the valve in this position is represented by *C*. If, however, the valve is rotated through a small amount, as shown by the dotted lines, it will be noted that the lead has increased to the amount shown by *D*, and consequently the cutoff made later. By this means it is possible to obtain a range of cutoff sufficient to carry a load varying between 75 per cent. of full load and 25 per cent. overload at the expense of the lead, and at the same time obtain better economy at all loads between these two positions than if the engine was controlled entirely at the throttle valve.

For electrical purposes standard practice is to make all engines capable of developing 25 per cent. overload, condensing, and capable of developing full load noncondensing when required. If an engine is controlled entirely by throttle governing, it is necessary that full boiler pressure should only be used at the maximum overload, or when running noncondensing, and when running under what should be the most economical load, viz., full load, the engine is using steam very considerably throttled. The diagram in Fig. 13 shows this point clearly, and it will be seen that when the engine is only controlled by the throttle valve throughout its range, the steam consumption per brake horsepower at full load is 16.4 pounds, whereas if the engine is fitted with an expansion gear and arranged so that the throttle governor only controls the engine between no load and 75 per cent. of full load, there is a saving of 0.8 pound per brake horsepower per hour, or 5 per cent. The steam consumption is also slightly better at 75 per cent. load, and if the average load on the engine ranges between 75 per cent. load and 25 per cent. overload, it will be seen that the saving in coal per annum is no small item.





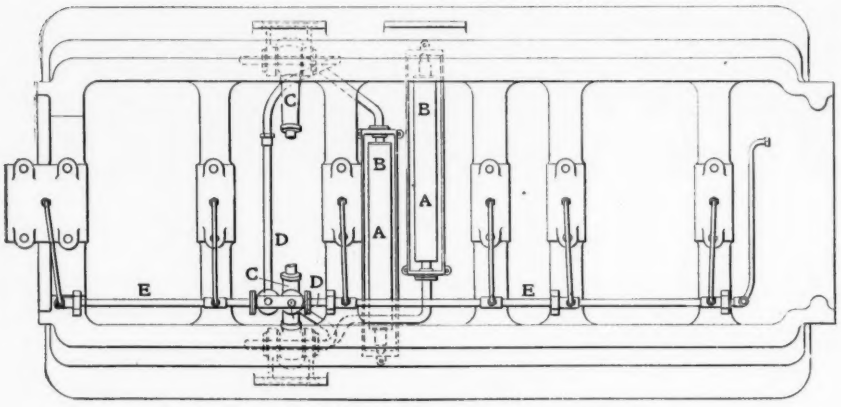


FIG. 14. SYSTEM OF FORCED LUBRICATION

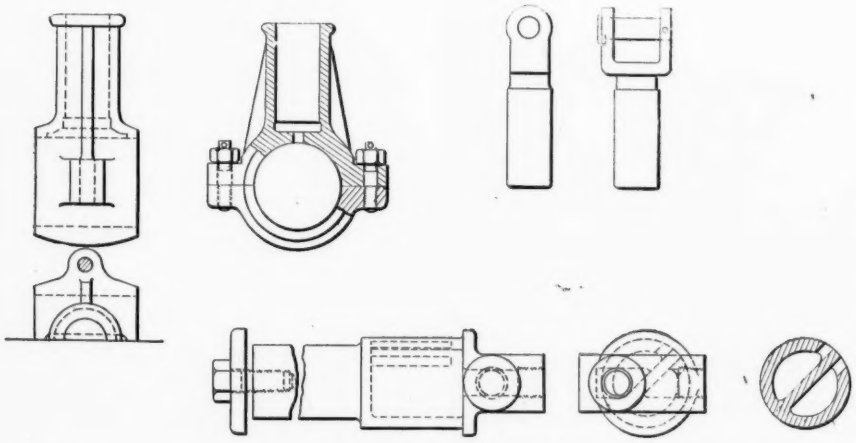


FIG. 15. OIL PUMP DETAILS

For instance, suppose an engine of 500 brake horsepower is working 12 hours per day and 6 days per week at an average load of between 75 per cent. load and 25 per cent. overload, the amount of coal required per annum will be 2000 tons, and taking coal at $2.50 per ton and an average saving of 5 per cent., as above, the amount saved will be $250 per annum.

Forced Lubrication

The system of lubrication may at first sight appear to be elaborate, but when considered in detail it will be found to be a simple arrangement. In Fig. 14 is illustrated the arrangement of forced lubrication as fitted to a three-crank triple-expansion engine. In the lowest part of the base are fitted two troughs *A A* into which are fitted strainers *B B*, which consist of perforated tubes around which is wrapped fine copper gauze. The object of the troughs is to prevent any dirt or sediment of any kind, which may be collected by the oil or get into the crank case, being drawn into the pump and so delivered into the main oil pipes. A certain amount of water also drips from the glands of the cylinders, and although additional glands are fitted at the top of the frame where the piston and valve rods pass through, leakage cannot entirely be prevented. If this water, however, does collect at the bottom of the base, it cannot be drawn into the pumps unless it is allowed to collect to such an extent that the level reaches to the top of the troughs. It is not likely therefore to cause any damage unless the engine attendant is careless, because the oil floating at the top of the

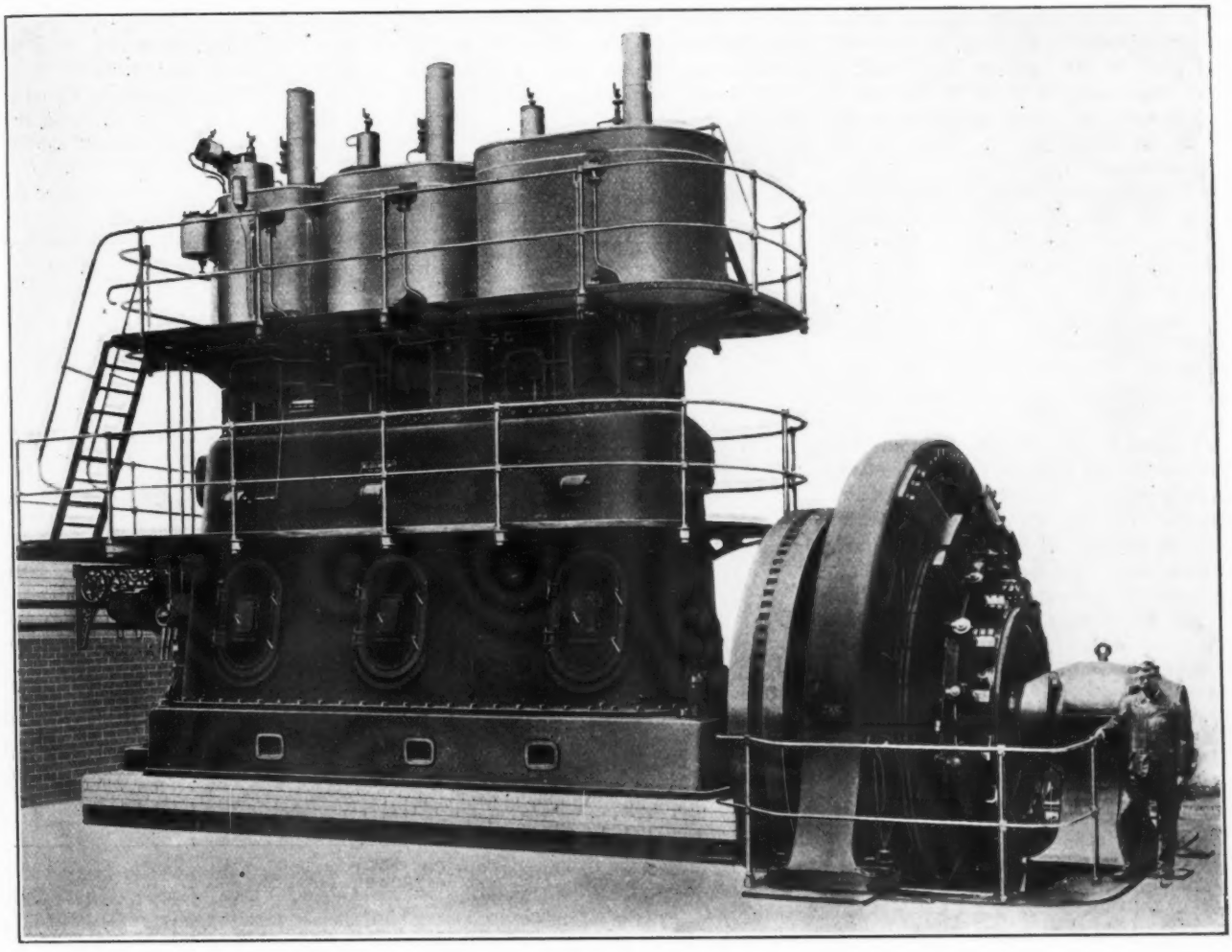


FIG. 16. BELLISS-DICK, KERR GENERATING SET

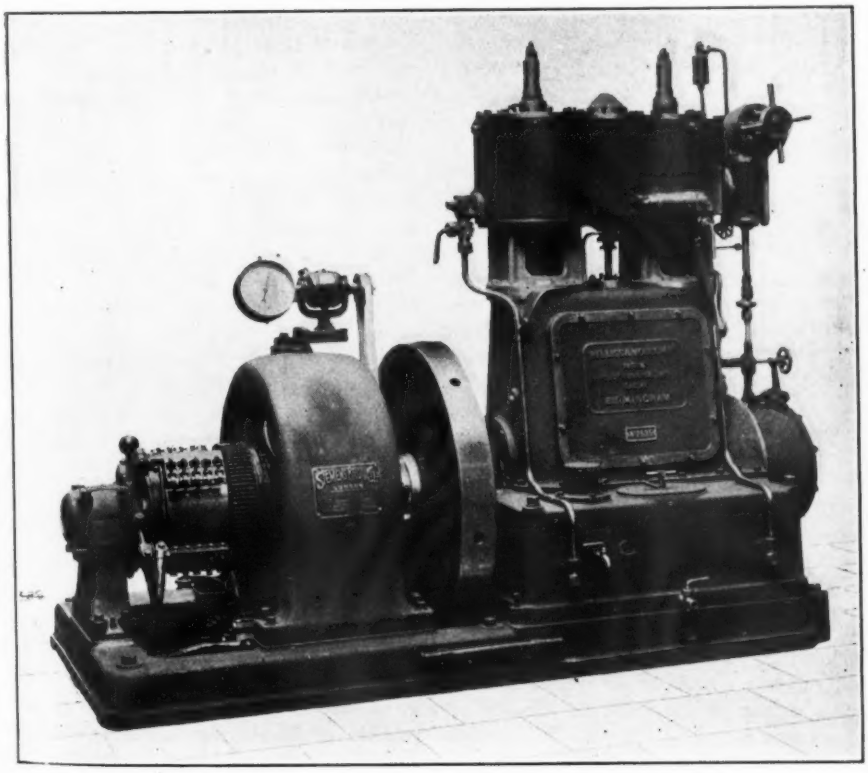


FIG. 17. SMALL TWO-CRANK BELLISS COMPOUND ENGINE

water overflows into the trough and is so delivered into the mains.

In the case of large engines similar to the one illustrated, it is usual to fit two oil pumps, each being of sufficient capacity to maintain the full oil pressure. These pumps are generally worked from one eccentric driving the valve gear and are of simple construction, viz., the valveless type. The oil pumps are shown at *C C*, and details of similar pumps are illustrated in Fig. 15. The drawing is self explanatory. The oil is delivered from the pumps through pipes *D D*, in Fig. 14, to the main oil pipe *E*, and from this main branches are taken, as shown, to each of the main bearings and crosshead slides. One end of the main pipe is coupled to a pressure gage by means of the pipe *F*, and a bypass valve is also fitted to this main so that the pressure may be regulated as required, the usual pressure being 15 to 20 pounds per square inch.

The crankpins receive their supply of oil by means of a hole drilled through the crankshaft from the center of the main bearings to the crankpin. One end of this hole is always in connection with a groove turned in the main bearings. In the crankpin brasses a similar groove is turned, and the oil is led through this

groove by means of a pipe attached to the side of the connecting rod up to the crosshead pin. In the case of small engines an additional groove is cut in the crosshead brasses and oil is conducted from this to the slides, but for large engines it is advisable to use a separate supply pipe direct from the main, as shown at *G* in Fig. 14. The eccentric and eccentric-rod crosshead pins, together with the crosshead slides, receive their supply of oil in a similar way, so that all of the working parts of the engine are automatically lubricated by means of the two pumps *C C*. The oil leaking from the various parts drips down into the crank case, but before being drawn into the pump again, it has to pass through the strainers already referred to. Where two pumps are fitted, a valve is generally attached to one end of the trough, so that when the strainer is withdrawn it automatically shuts off the supply of oil to that pump, and thus prevents the possibility of any grit being drawn in. It is thus possible to remove and clean a strainer while the engine is running.

Standard Makes of High-speed Engine

Belliss & Morcom. The largest firm of high-speed engine builders in England is Messrs. Belliss & Morcom, Ltd., of Birmingham. This firm alone has manufactured over 3000 engines. The largest engines built are suitable for driving generators of 1500 kilowatts capacity, and in Fig. 16 is shown a photograph of one of the Belliss-Dick, Kerr sets installed in the new Summer Lane electricity-supply station of the Birmingham Corporation.

Eight of these sets are installed and each is capable of developing as a continuous output 1500 kilowatts and 25 per cent. overload for short periods of time. They run at 166½ revolutions per minute and are supplied with steam at a pressure of 180 pounds per square inch. The normal output in brake horsepower is 2140, the maximum being 2680.

Of each set the high-pressure cylinder is 25 inches in diameter, the intermediate 36½ inches, and the low-pressure 55 inches, the stroke being 33 inches. Piston valves are fitted to all cylinders, these being driven direct from the crankshaft by a single eccentric. Messrs. Belliss' patent automatic-expansion gear, which is very similar to that previously described, is fitted to the high-pressure cylinder, the position of the valve being determined by a special relay cylinder which is operated from the governor controlling the throttle valve. With this arrangement the engine is governed by automatic expansion at the high loads and by the throttle at light loads.

In Fig. 17 is illustrated a small two-crank compound engine built by Messrs. Belliss & Morcom for the Peninsular and Oriental steamship "Mooltan. This engine is shown coupled to a Siemens dynamo capable of developing 40 kilowatts, the engine being capable of developing 58 brake horsepower when running at a speed of 450 revolutions per minute. The

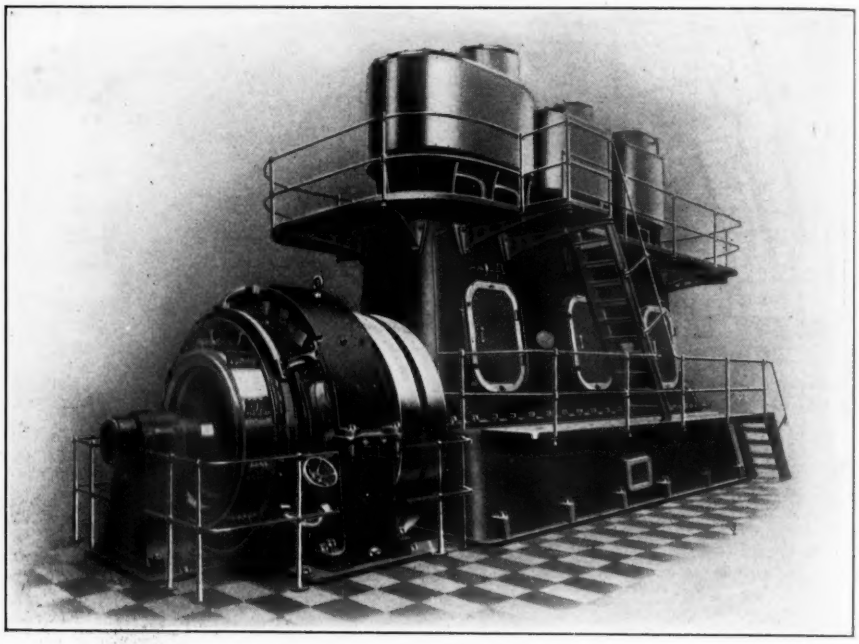


FIG. 19. EXTERIOR OF BROWETT-LINDLEY ENGINE

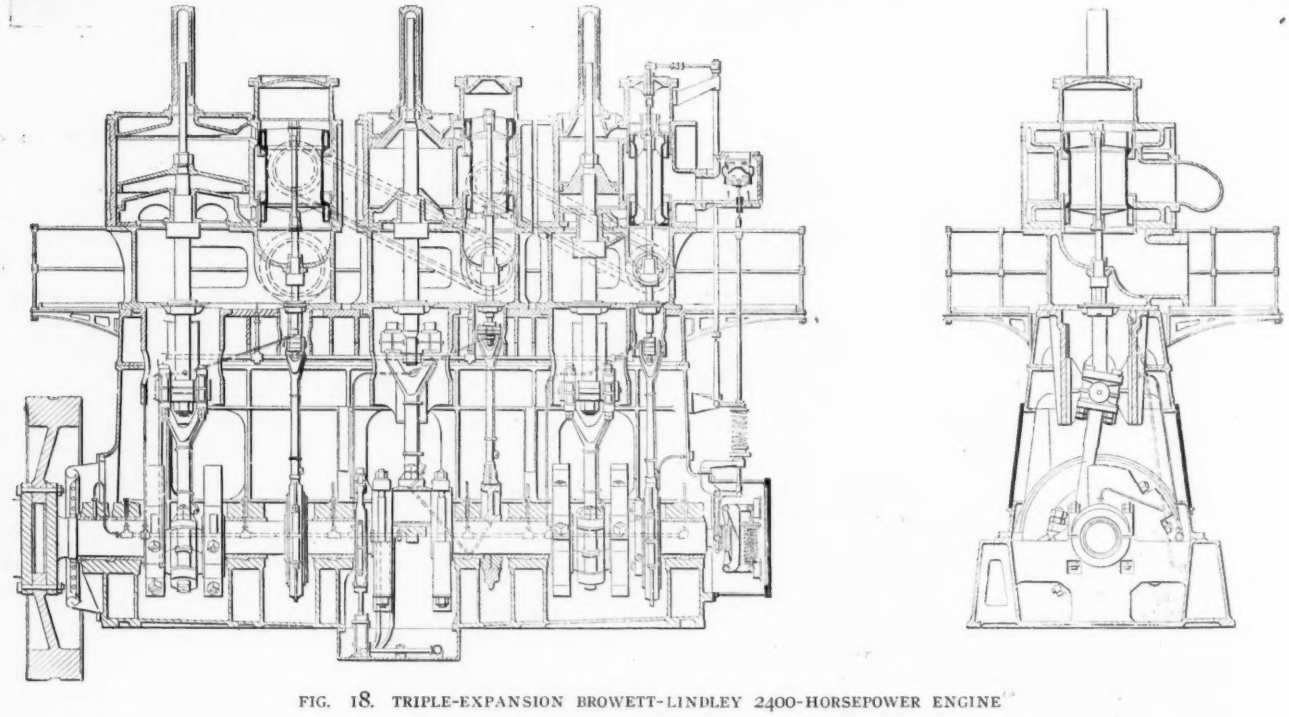


FIG. 18. TRIPLE-EXPANSION BROWETT-LINDLEY 2400-HORSEPOWER ENGINE

sets, of which there are five installed, supply current for 1400 incandescent lamps of 16 candlepower each, four hundred 12-inch electric fans, six forced-draft fans, four large ventilating fans, a searchlight of 8000 candlepower, six coaling lamps of 20,000 candlepower, electric headlight and sidelights and two Brockie-Bell lamps of 40,000 candlepower each.

Browett, Lindley. Another large firm which manufactures engines of all powers from 20 to 3000 horsepower are Messrs. Browett, Lindley & Co., Ltd., of Patricroft, Manchester. This firm manufactures engines in the usual varieties, viz., single-crank simple and compound engines, two- and three-crank compound engines and three-crank triple-expansion engines. Their standard design of two-crank compound engine has already been illustrated in Fig. 3, and this drawing shows generally the arrangement of cylinders and motion work of the engine.

Engines of the type illustrated in Fig. 3 are manufactured in powers ranging from 300 to 1000 horsepower. The productions of this firm are undoubtedly of substantial design and material is not in any way stinted throughout the engine. All parts are accessible and at the same time the frame work of the engine is unusually rigid.

In Fig. 18 is shown in full section one of the largest-sized engines manufactured. This engine is capable of developing 2400 indicated horsepower as a normal load and 3000 as a maximum for periods of about two hours. It is of the triple-expansion type and has cylinders 25x39x60 inches in diameter and a 27-inch stroke. It will develop the power stated when running at a speed of 200 revolutions per minute if supplied with steam at a pressure of 150 pounds per square inch and exhausting into a condenser. Piston valves are used throughout, and the cut-off of the high-pressure valve is under control of the governor, so that when working at the higher loads the engine is governed by variable expansion. At lighter loads throttling takes place in combination with the alteration to the cutoff.

The crankshaft for this engine is forged in one piece, and the flywhel bolted to a large coupling formed at one end. The bolts in this coupling pass right through the crankshaft, flywheel and dynamo coupling, so that no energy has to be transmitted through the crankshaft due to any shocks which may be received from the generator end. The economy of the high-speed engine compares most favorably with the best engine on the market, and this size of engine requires only 11.8 to 12.4 pounds of steam per brake horsepower when supplied with steam at a pressure of 150 pounds, superheated 100 degrees Fahrenheit, and working condensing at 26 inches of vacuum. The figures quoted are not results obtained from one particular engine, but represent what is obtained in every-day practice from a large number of engines. An exterior view of the engine illustrated is given in Fig. 19.

The Problem of Furnace Design for Water-tube Boilers

By Harold V. Coes

The water-tube boiler, while possessing many advantages for large power units, has one distinct inherent disadvantage in the difficulty of obtaining perfect combustion in the furnace as now designed. Until very recently and even now, with a few exceptions, it has been the practice to place the relatively cold heating surface in direct contact with the flames, thus defying at the very outset one of the laws governing complete and perfect combustion.

Messrs. Booth and Kershaw, in their work entitled "Smoke Prevention and Fuel Economy," lay down the following requisites for perfect combustion:

1. A draft velocity, of not less than 30 feet per second, over the fire to draw in air above the fire bed, for combination with the gases distilled from the freshly charged fuel.

2. A thorough mixing of this air with the fuel gas, which can usually be done by allowing the air and gas to flow together over the length of the furnace. The air must be admitted in numerous fine jets, as through a perforated plate in the door.

3. A sufficient temperature to insure ignition at the bridge end of the furnace.

4. Space in which the combustion can complete itself undisturbed.

Consider the water-tube boiler and see how many of these requisites are violated or observed, and why, and how to remedy the shortcomings.

Unless horizontal baffles or arches are used, the air entering the doors short-circuits and passes directly up the tubes. It is true that the tubes mix the gases and air, but this is after the temperature has been reduced, so that if they do unite, it will be at some point beyond the tubes, where the heat derived cannot be effective. Consequently, the gas and air pass up the tubes unmixed instead of being thoroughly mixed and passing over the fire. Since each component of the fuel requires a definite amount of air to oxidize it, and since the gas and the air have to be thoroughly mixed to attain this result, if the tubes are set close to the grate, as in the water-tube boiler (thus chilling the flames), the highest temperature is not reached. Some of the hydrocarbons cannot be burned or oxidized except at high temperature, and as we both lower the temperature and do not mix the gases and air we violate the third requisite.

By placing the tubes close to the grate, we violate the fourth essential of good combustion, as one of the most important considerations in the design of a furnace is the combustion chamber.

Character of Fuel the First Thing to be Considered

The first thing to be considered in the design of the combustion chamber is the character of the fuel to be burned. The ignoring of this fact is responsible for a great many failures to attain perfect combustion. Trying to burn high volatile bituminous coals under a water-tube boiler with an anthracite setting causes still more failures and dissatisfaction. The greater the volatile content of the coal the more difficult becomes the problem. In burning the fine grades of anthracite, such as that from the mines of eastern Pennsylvania, the heating surfaces can be set relatively close to the grate, as there are practically no volatile hydrocarbons distilled from such coals, and as the flame length is proportional to the volatile matter in the fuel.

In such cases the tubes near the bridge-wall may be only a few feet from the grate and give good results; but the moment high volatile coal is burned under this setting trouble begins, as it is absolutely impossible to operate a boiler under these conditions without objectionable smoke and a correspondingly low furnace efficiency. The reason for this is that the high volatile fuel burns with long flames, and if the tubes or heating surfaces are not sufficiently removed to prevent the flames from impinging on it, and before the flames can be properly mixed with the requisite amount of air, they are chilled to a point below the combustion temperature. This causes the carbon to be precipitated either in the form of soot or smoke and, as smoke, to pass off up the stack with the rest of the products of combustion in a dense black cloud, which is sure evidence of poor heat transference and poor combustion.

The fact that this takes place in some water-tube boilers using soft coal on the grates is due primarily to the fact that in many instances water-tube boilers equipped with anthracite grates and settings were used in soft-coal districts, with the consequent results of poor combustion and low efficiency.

It is thus plainly seen, and this is the main point for consideration, that the furnace should be designed for and adapted to the fuel to be used in it.

How to Remedy Some of the Defects

The combustion chamber should be of such size that combustion can be complete and undisturbed and permit the flames to burn out before coming in contact with the heating surface. As previously stated, the length of a flame is in almost direct proportion to the volatile content of the fuel, depending somewhat on the composition or the constituents of

this volatile matter. The short-circuiting of the air and gases and the prevention of the flames from reaching the heating surfaces can be accomplished simultaneously by the use of firebrick arches, tile roofs or dutch ovens; although the dutch oven is seldom used except with some form of automatic stoker.

One of the most effective ways of increasing the volume of the combustion chamber and of keeping the volatile gases from contact with the tubes in a water-tube boiler, is to build a tile roof across the furnace, covering up the lower portion of the first and second passes and reversing the circulation of the gases, the products of combustion now passing first over the bridgewall, up through the third pass, down to the second and up the first pass to the flue. This constitutes a dutch oven to all intents and purposes in the boiler itself.

The length of this tile roof or flat arch depends upon the flame length, for the flames should be extinguished or burnt out before going up the pass. And as stated before, the flame length depends upon the volatile content. The longer this arch is made the longer is the travel of the hydrocarbons in contact with it, and consequently the longer is the time interval for perfect combustion to take place. With the lower volatile Eastern coals, this arch need not be over 4 feet in length in order to obtain complete combustion. As the percentage of volatile matter increases the length of the arch or roof increases in almost direct ratio. It is also affected by the rate of combustion, so that with a knowledge of these two elements a furnace setting can be designed which will be absolutely smokeless under all operating conditions.

One type of arch which has given satisfaction, especially when used with fine anthracite, is that used in the Webster furnace. This consists of several arches strung across the grate in such a manner as to prevent the cooling of the fire when the charging doors are open. These arches are particularly effective when induced draft is used, as the difference in static pressure may in this case amount to several tenths of an inch of water, causing an inrush of cold air as soon as the doors are open and the consequent chilling of the tubes and lowering of the furnace temperature, unless the foregoing means are used to prevent it.

Hight of Boiler Tubes Important

A very important consideration irrespective of the type of furnace is the hight of the boiler tubes above the floor, or, what amounts to the same thing, above the grate. This again, of course, depends upon whether a tile roof is used or not. Formerly it was customary to install the Babcock & Wilcox boiler with the bottom of its header from 7 to 7½ feet above the floor line. This distance has gradually been increased for burning high volatile bituminous coals to 9 feet, and in some recent installations has been placed 10 feet above the floor line. And even this figure will probably be increased under some new gravity underfeed stokers.

The tile roof, furthermore, has a reverberatory action which keeps the furnace temperature at maximum, thus insuring the ignition temperature of the hydrocarbons and a heating of the air passing over the fire, with a thorough mixing of these two elements and the resulting good combustion. If the air for combustion can be preheated by any of the advantageous methods at disposal, the better will be the combustion.

The use of steam jets and that type of apparatus should not be tolerated, for they do little if any good, and that at the expense of good combustion. Operating engineers believe that they prevent clinkers. The only reason that a steam jet stops clinkers is because it lowers the furnace temperature below the fusing point of the clinker, which is a good reason for not using it, since any agent that tends to lower the temperature of combustion is a poor one.

There is a method, however, for small installations which merits consideration, and that is a combination turbine-driven disk fan, which uses a very small percentage of exhaust steam, but which materially aids in distributing the air for combustion. Of course for large installations some one of the mechanical-draft installations would be used. But then, again, large installations generally have an engineering staff capable of properly designing and specifying the kind of furnace to be used.

Amount of Coal Burned

The amount of coal that can be burned per square foot of grate surface per hour varies over a wide range for various installations and various conditions. The problem depends upon the load to be carried, kind and amount of draft, type of boiler and the character of the fuel. In some of the large central stations using the finer grades of anthracite this amounts to from 25 to 30 pounds. During the peak load, by increasing the draft, this figure may be increased to 50 pounds per square foot.

With soft coal, except where stoker-fired, it is not generally good practice to burn more than about 20 pounds per square foot on a flat grate, on account of the difficulty of good air distribution. When soft coal is fired with an automatic stoker, as is done in large stations, from 65 to 70 pounds of coal per square foot of grate per hour may be burned. This has recently been done by a new type of gravity underfeed stoker.

The type of grate to be used is a matter of choice, there being many good types on the market. Whether a dumping or a shaking grate will be used depends upon the amount of ash and clinker in the fuel. If this is rather small the shaking grate will give good results; if high, then the former should be used.

The one thing to bear in mind is the fact that the burning of coal is governed by just as accurate physical laws as is the generation of steam. Just as much care, thought and time should be spent upon the design and selection of a furnace as upon any other part of the boiler. For after all, this is the heart of the boiler, and any saving that is made in the furnace is a direct saving, for no processes of manufacture have taken place until the coal is fired; consequently, the saving in raw material represents hard cash.

The Function of Compression

By R. T. Strohm

Judging by what one reads and hears, the question of compression or no compression seems to be causing no little mental agitation. There are those who have come out broadly for the elimination of the compression heel from the indicator diagram, on the ground that compression in steam engines is not necessary, and that most engines would run better, both mechanically and economically, if it should be dispensed with.

Such statements, to say the least, are combatable. To begin with, it is rather absurd to think that steam engineers have been making the egregious blunder, for many decades, of clinging to compression and thereby wasting steam. It is scarcely believable that if eliminating compression increases economy, the fact would not ere this have been discovered and put to practical use. Engine builders who have guaranteed certain definite results as to economical performance have designed and manufactured engines in which compression figures largely. Is it possible that they have thus long been ignorant of the suggested means of lowering steam consumption?

Argument of this character, alone, does not nullify the statement that compression is unnecessary. That much is admitted. But there are other ways of attacking the problem. Compression in steam engines is not only desirable, to a greater or less extent, but is a necessity. There are two good reasons for this condition. One is that silent and smooth running is thereby secured. The other, and just as important reason, is that the economy of the engine is improved thereby. It will be observed that these statements are diametrically opposed to those referred to in the opening paragraph. It now remains to adduce something in the way of support and proof.

The reciprocating parts of an engine do

not move with a uniform velocity. Instead, the velocity increases from zero at the beginning of the stroke to a maximum at the middle of the stroke, and then decreases to zero at the end of the stroke. During the period of acceleration, the pressure of the expanding steam is the force causing the acceleration. But during the period of retardation, the retarding force may be either a cushion of steam, a reaction from the crank pin, or a combination of the two. If compression is used, the increasing pressure of the steam trapped in the compression space will furnish the resistance necessary to overcome the inertia of the reciprocating parts, and it is evident that, by adjusting the amount of compression, the reciprocating parts may be brought to rest without subjecting the crank pin or wrist-pin to any great pressure.

In Fig. 1 is shown a curve of inertia pressures in a reciprocating steam engine, *a b* representing the stroke, and vertical distances from *a b* to *d e* representing inertia pressures. It will be seen that at the beginning of the stroke, the inertia pressure is negative, and of a value *a d*. As the parts become accelerated, the inertia pressure grows smaller, until, at the point of maximum velocity *c* the inertia pressure is zero, since at that point the crank pin and crosshead are moving with the same linear velocity. From *c* to *b* the crosshead motion decreases in velocity, and at *b* the inertia pressure *b e* is again large, but this time positive in value. The increase of velocity of the reciprocating parts during the portion of the stroke represented by *a c* is due to the expenditure of a portion of the energy of the expanding steam. The decrease of velocity from *c* to *b* is due to the fact that the reciprocating parts are giving up the energy received during the earlier portion of the stroke.

If the reciprocating parts are brought to rest by means of a cushion of compressed steam, the resisting force increases from zero to a maximum, just as the inertia pressure changes in similar fashion; and furthermore, this resistance is introduced against the piston, which forms a large proportion of the weight of the reciprocating parts, and this point of application of the resistance is therefore the most direct and the most rational. If no compression is used, the inertia thrust of the rapidly moving parts will be transmitted to the crank pin with ever increasing intensity.

Now, is it not manifestly better to bring the reciprocating parts to rest by a cushion of steam than by the influence of the crank pin? By means of the steam cushion, the pressure is transmitted directly to the cylinder head, which in turn is attached to the most rigid portion of the engine frame. As a result, the inertia of the reciprocating parts is absorbed, and they are brought to rest with the least unbalancing or vibrating effect. On the other hand, if the reaction at the crank pin is relied upon to accomplish the desired end, the pressure is applied through intervening links in the connections of which some play exists, and the tendency is to produce pounding. The balancing of an engine to overcome the disturbing effects of the rotating and reciprocating parts is a very pretty problem, indeed, and while there are a few engines in which a practically perfect balance has been secured, there are many that are far less accurately balanced, and the elimination of compression from such engines would be followed by running conditions that no sane engineer would regard as desirable or safe.

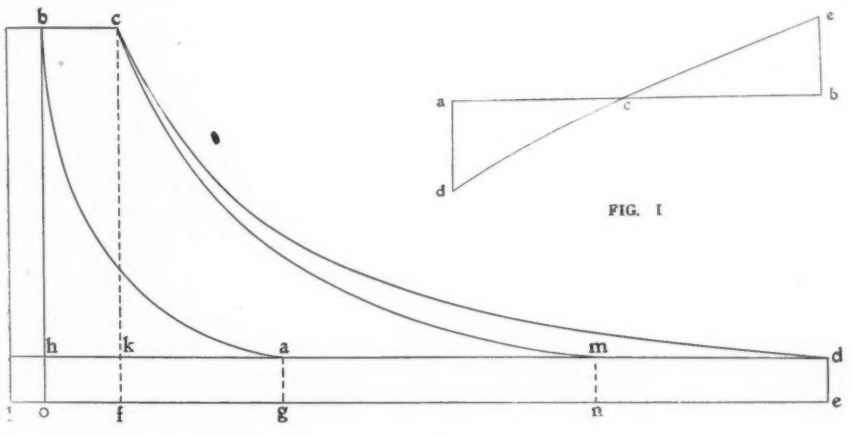


FIG. 2

FIG. 1

Using Flywheel Energy Not Wasteful

It has been argued that it is a wasteful proceeding to use part of the energy stored in the flywheel to compress the steam entrapped in the clearance space. This idea is based on a misconception, surely. It is not necessary to take any considerable energy out of the flywheel to accomplish compression. If the point of compression is so chosen that the amount of energy required for compression is just equal to that given up by the reciprocating parts in coming to rest, it will be unnecessary to take additional energy from the flywheel. This would be the ideal condition, as far as smooth running is concerned.

But there is another side to the question of compression. Compression is of practical value in neutralizing the evil effects of clearance on the steam consumption. There will be few engineers to combat the statement that clearance is a mechanical necessity. As long as bearings and pins are subject to wear, just so long will it be necessary to allow a greater or less amount of clearance between the piston and the cylinder head at the extreme ends of the stroke. Now, the effect of clearance is to increase the steam consumption per unit of work done, and the greater the clearance, the greater is the loss. This can be very readily shown by illustrative examples.

Take a case in which 1 cubic foot of steam at 105 pounds per square inch, absolute, is expanded to a pressure of 15 pounds, absolute, there being no clearance and no compression. Under these conditions, the ratio of expansion is 7. The work during expansion or compression according to the law $P V$ = a constant is found by the formula

$$W = 2.3026\ P_1\ V_1\ log.\ \frac{V_2}{V_1},$$

where

W = Work in foot-pounds,
P_1 = Initial absolute pressure, in pounds per square inch,
V_1 = Initial volume, in cubic feet,
V_2 = Final volume, in cubic feet.

Since the expansion of saturated steam follows most closely the equilateral hyperbola, $P V$ = a constant, the above formula will be used in calculating the work areas under the curves in Fig. 2. Also, where rectangular areas are concerned, the work may be found by the formula

$$W = P_1\ (V_2 - V_1),$$

in which the several letters have the same significance as before.

In Fig. 2, let *b c* represent 1 cubic foot of steam at a pressure of 105 pounds per square inch, absolute, the pressure being represented by the hight *o b*. First, assume neither clearance nor compression, and let the steam expand to the pressure of the atmosphere. Then the expansion curve is *c m*, and the work represented by the several areas, as found by the foregoing formulas, is

$$c\ m\ n\ f = 2.3026 \times 105 \times 144 \times log\ 7 = 29{,}422\ foot\text{-}pounds.$$

$$b\ c\ f\ o = 105 \times 144 \times 1 = 15{,}120\ foot\text{-}pounds.$$

$$b\ c\ m\ n\ o = 29{,}422 + 15{,}120 = 44{,}542\ foot\text{-}pounds.$$

$$h\ m\ n\ o = 15 \times 144 \times 7 = 15{,}120\ foot\text{-}pounds.$$

Therefore, $b\ c\ m\ h = 44{,}542 - 15{,}120 = 29{,}422$ foot-pounds, the amount of work

done by 1 cubic foot of steam with no clearance nor compression.

Now, add 0.5 cubic foot for clearance, as indicated by *o l*. Then, in reducing to 15 pounds pressure, as before, the piston will sweep through 10 cubic feet, and the final volume of the steam will be 10.5 cubic feet. As the initial volume was 1.5 cubic feet, as represented by *f l*, the ratio of expansion remains unchanged. Then,

$$c\,d\,e\,f = 2.3026 \times 105 \times 144 \times 1.5 \log 7 = 44{,}133 \text{ foot-pounds.}$$

$$b\,c\,f\,o = 105 \times 144 \times 1 = 15{,}120 \text{ foot-pounds.}$$

$$o\,b\,c\,d\,e = 44{,}133 + 15{,}120 = 59{,}253 \text{ foot-pounds.}$$

$$h\,d\,e\,o = 15 \times 144 \times 10 = 21{,}600 \text{ foot-pounds.}$$

Therefore, $b\,c\,d\,h = 59{,}253 - 21{,}600 = 37{,}653$ foot-pounds. This amount of work was accomplished by 1.5 cubic feet of steam, so that the work per cubic foot was $37{,}653 \div 1.5 = 25{,}102$ foot-pounds, as compared with 29,422 foot-pounds without clearance. This shows the manner in which adding clearance decreases the work done per unit of steam used.

Now assume compression to commence at *a*, so that when the piston reaches the end of its stroke there will be 0.5 cubic foot of steam at 105 pounds absolute pressure in the clearance space. Under these conditions the clearance space is filled with steam at the initial pressure, so that the amount admitted up to cutoff is merely that represented by *b c*, or 1 cubic foot. The work of compression is represented by the area *o b a g*, and as before it is found that

$$o\,b\,a\,g = 2.3026 \times 105 \times 144 \times 0.5 \log 7 = 14{,}711 \text{ foot-pounds.}$$

Also,

$$g\,a\,d\,e = 15 \times 144 \times 7 = 15{,}120 \text{ foot-pounds.}$$

The area *a b c d* representing the net work performed is equal to

$$o\,b\,c\,d\,e - o\,b\,a\,g - g\,a\,d\,e = 59{,}253 - 14{,}711 - 15{,}120 = 29{,}422 \text{ foot-pounds.}$$

The total work done with a clearance of 0.5 cubic foot and no compression was 44,133 foot-pounds, and the total work with neither clearance nor compression was 29,422 foot-pounds. The difference between these is 14,711 foot-pounds, which must be represented by the area *c d m*. But, the area *o b a g* also represents 14,711 foot-pounds. In other words, the gain due to increased expansion after adding clearance is exactly offset by carrying compression up to the initial pressure, and the net work, represented by the area *a b c d*, accomplished by 1 cubic foot of steam is equal to the work obtained from the same amount of steam expanded without clearance or compression, since in each case the work amounts to 29,422 foot-pounds.

This proves conclusively that when compression is carried up to the initial pressure, so that the clearance space at the beginning of the stroke is filled with steam at the admission pressure, the wasteful effect of clearance is nullified, and the steam economy is the same as though there was no clearance nor compression.

It is possible that someone may argue that in ordinary cases the compression is not carried up to the initial pressure, and that during compression there is a definite loss due to radiation and condensation of the entrapped steam. These facts are freely admitted. But such an admission does not destroy the truth of the statement that compression is economical. It has been shown that the evil effect of clearance is wholly offset by compressing to the initial pressure. If the compression is less than this, the saving is correspondingly decreased, but in any case it is better than dispensing with compression altogether, and filling the clearance space with live steam at the beginning of each stroke. For this steam does no work on the piston until after the valve closes, and then, by its expansion, it adds somewhat to the diagram, as indicated by the area *c m d*, Fig. 2.

Finally, the necessity of having compression grows less as the speed of the reciprocating parts or the percentage of clearance decrease. In high-speed automatic engines the clearance is usually large, and it will be found that, almost without exception, diagrams from this class of engine show compression curves running from two-thirds to three-fourths the hight of the diagrams. In Corliss engines the percentage of clearance is much less and the piston speed is lower, and in many such engines it is possible to reduce the compression to such a degree that the heel of the diagram is almost square, without affecting the smoothness of operation or steam economy of the engine. But though this may be done in the case of slow-speed engines having small clearance volumes, and has been successfully demonstrated in such cases, it ought not to be formulated into a general statement and heralded as being applicable to all types and classes of engine. For most assuredly it is not.

Central Electric Light and Power Stations in the U. S.

In the accompanying table are shown the data of a preliminary report, by the Department of Commerce and Labor, on central light and power stations in the United States, exclusive of Alaska, Hawaii, Philippine islands and Porto Rico.

PRELIMINARY REPORT ON CENTRAL ELECTRIC LIGHT AND POWER STATIONS.

	1907.	1902.	Per Cent. of Increase.
Number of establishments	4,714	3,620	30.2
Commercial	3,462	2,805	23.4
Municipal	1,252	815	53.6
Total cost of plants	$996,613,622	$504,740,352	97.5
Total income (1)	$175,642,338	$ 85,700,605	104.9
Lighting service	$125,755,114	$ 70,138,147	79.3
All other electrical service	$ 43,859,577	$ 14,048,458	212.2
All other sources	$ 6,027,647	$ 1,514,000	298.1
Total expenses	$134,196,911	$ 68,081,375	97.1
Salaried employees:			
Number	12,990	6,996	85.7
Salaries	$ 11,733,787	$ 5,663,580	107.2
Wage-earners:			
Average number	34,642	23,330	48.5
Wages	$ 23,686,537	$ 14,983,112	58.1
Supplies, materials and fuel	$ 44,458,568	$ 22,915,932	94.0
All other expenses (including interest on bonds)	$ 54,318,019	$ 24,518,751	121.5
Steam and gas engines (including turbines):			
Number	7,674	6,095	25.9
Horsepower	2,684,228	1,392,122	92.8
Water wheels:			
Number	2,474	1,390	78.0
Horsepower	1,347,487	438,472	207.3
Total kilowatt capacity of dynamos	2,642,403	1,218,735	116.8
Output of stations, total kilowatt-hours	5,858,121,860	2,507,051,115	133.7
Estimated number of lamps wired for service:			
Arc lamps	(2) 555,921	385,698	44.1
Incandescent lamps	(2) 41,807,944	18,194,044	129.8
Stationary motors served:			
Total horsepower capacity	1,649,026	438,005	276.5

(1) Exclusive of income for current used for light and power that was furnished by railway companies, and which is included in the report for street and electric railways.
(2) Exclusive of lamps used by the establishments reporting to light their own properties.
The final report will contain an analysis of the above totals and present detail statistics by States and for other phases of the industry.

The statistics relate to the years ending December 31, 1907, and June 30, 1902. The totals include central stations only. They do not include isolated plants, or plants that were idle or in course of construction, and in but few instances plants operated by electric-railway companies.

It is interesting to note that in connection with the conservation of water power a recent advance in transmission voltage, by the placing in service of a 110,000-volt line in Michigan, is a clear indication of the rapid elimination of distance as an obstacle to electric-current service.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Independent Steam Gage Movements

I was much surprised to see a description of a steam-gage movement which is mounted upon the base of the spring, so as to be independent of the case, appear in a recent issue of POWER as a new thing. I am sure that it has been upon the market for seven or eight years, and it is not at all original with the company to whom it is credited in the description. The description mentions among the advantages of this construction that "jar and vibration do not affect its accuracy nor sensitiveness." I think that experience has shown that jar and vibration have more effect on a gage of this type than they do on a gage where the movement is fastened to the back of the case, although there is not a great difference, and what is true of one is as true of the other.

It has never been proved that the air space at the back of the case was beneficial in any way, due to the fact that when the necessary amount of heat reaches the case to cause it to expand, as well as the movement, to such an extent that the reading of the gage would be affected, this amount of heat would, before the reading would be affected due to expansion, damage the tube to such an extent that the gage would be useless, anyway.

H. E. TRAVERS.

Pittsburg, Penn.

Solution on Indicator Cards

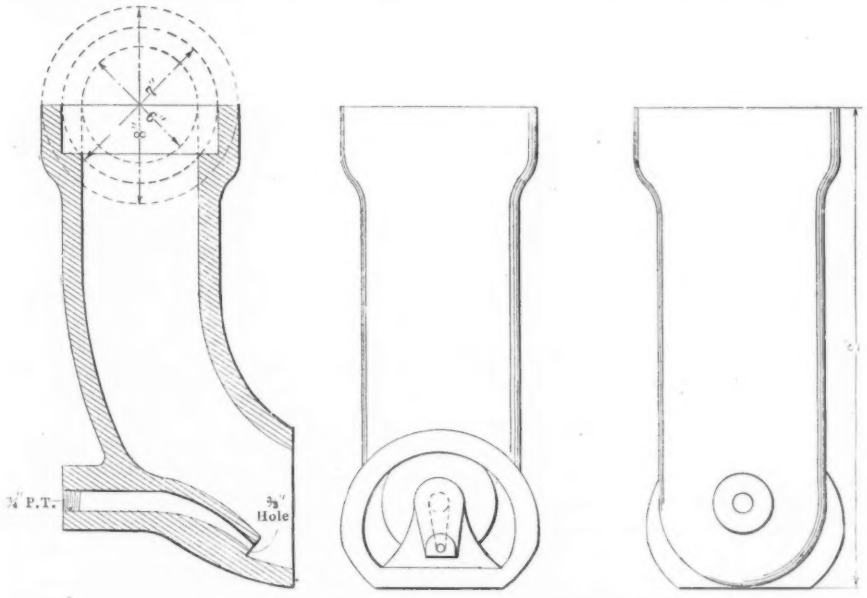
Can any reader inform me what solution is used on prepared indicator cards and how it is applied?

D. O. BARRETT.

Freeport, Ill.

A Sawdust Stoker

In a large sawmill boiler room were 11 boilers, two of which were fitted with dutch-oven furnaces and hand-fired. The remaining nine boilers were divided into two batteries of two boilers each, and one battery of five. There was no dividing wall between the boilers of each battery, the boilers being hung from I-beams.



COMPRESSED-AIR OR STEAM SAWDUST DISTRIBUTOR

The sawdust was carried by overhead chain conveyers and dropped through openings between the boilers.

Combustion under these conditions was very unsatisfactory, as a large cone of sawdust was formed under each spout, and between each cone was a large area of bare grate. A plan which worked well was to arrange things so that the sawdust falls into the curved pipe shown in the illustration, and is then blown into the furnace by a jet of steam or compressed air. The jet strikes the edge of the casting in such a manner that the sawdust spreads out like a fan, covering the entire grate surface.

T. HENRY.

Toronto Junction, Can.

Compound versus Simple Engines

In a recent number were published a letter and indicator diagrams, by George W. Harding. The diagrams were intended to prove that a compound engine develops twice the horsepower that a simple engine does.

The data furnished with Mr. Harding's diagrams show that the receiver pressure was from 15 to 19 pounds, gage, and the vacuum was from 21 to 22.5 inches. Now, if this had been a simple engine it would have been exhausting into 21 or 22 inches of vacuum instead of 15 to 19 pounds gage pressure. Mr. Harding's diagrams only show that the work was nearly equally divided between the high- and low-pressure cylinders, nothing more.

He wishes to know why engines are compounded if not to develop more work by again using the steam that has done work in the high-pressure cylinder. Engines are not compounded to develop more power, but to save fuel. It is cheaper to build a 200-horsepower simple engine than a 150-horsepower compound engine. It would seem that the compound engine is not as generally understood as it should be by many engineers.

Let us see what advantage the compound engine really has over the simple engine. For example, take two engines of 100 horsepower each, one a compound, the other a simple engine. The steam pressure will be 150 pounds gage for each engine. The condenser will be left out of the problem and the steam expanded in each engine to atmospheric pressure, thus getting the same power from each engine, exhausting at the same pressure and having the same boiler pressure in each case. Steam at 150 pounds gage has a temperature of about 366 degrees Fahrenheit, while steam at atmospheric pressure is only 212 degrees, a difference of 154 degrees Fahrenheit. As the walls of the cylinder are cooled nearly to the temperature of the steam at the time of exhaust, it will be understood that when steam at 366 degrees Fahrenheit is admitted the initial condensation is very great in the simple engine, while with the compound engine the exhaust from the high-pressure cylinder can never fall below the receiver pressure. Mr. Harding's receiver pressure was about 19 pounds gage, or about 257 degrees Fahrenheit, so it may be seen that the ratio of cylinder condensation is considerably less

in the compound engine than in the simple engine; therefore, there is a greater economy in favor of the compound engine.

C. E. Bascom.

West Halifax, Vt.

Finding Engine Clearance from Indicator Diagrams

In a recent number a writer presented two methods for finding engine clearance from the indicator diagram, which were incorrect in one important and essential point, as he used the atmosphere line as a base line, while as a matter of fact the atmosphere line has nothing to do with the determination of clearance.

The correct method of obtaining the clearance from the diagrams is as follows: Select the best diagrams that can be obtained from the engine, having smooth expansion and compression curves. Lay off the absolute zero-pressure line parallel to the atmosphere line and at a distance below it to represent 14.5 pounds on the scale of spring used for the diagram. Draw the line *A B C D*, Fig. 1, cutting the smoothest portion of the expansion or compression curve at the points *B* and *C*. Then locate the point *D* so that the distance *C D* equals *A B*; the perpendicular line *D E* will then represent the point of zero volume, and the per cent. of clearance may be obtained by dividing the length *E F*, in inches, by the length of the diagrams *F G*, in inches, and multiplying by 100.

The explanation for this construction is that the expansion curve and compression curve for saturated steam, and for air when the compressor is running very slowly, are nearly enough in form to an equilateral hyperbola, whose axes are the zero-volume line (clearance line) and the absolute zero-pressure line, that they may be assumed to be so. On such a curve, if a line such as *A B C D* be drawn intersecting the curve in two points and touching the two axes, then it is true that the two portions *A B C D* are equal.

If the second method should be used the line which is an extension of the diagonal of the constructed rectangle should be continued to the absolute zero-pressure line. This method should not be recommended, as there are too many chances for error in construction, and it is more difficult to get right.

If the engine is an old high-speed machine, there is a chance that leaks in the valve or error in the indicator will show on the expansion line, and in this case it is better to use the compression curve, Fig. 1.

On many Corliss engines, and others of slow speed, the compression may be so short as to give a very small curve, and then the construction must be on the expansion line, Fig. 2. In any determination of this kind the greatest care must be exercised to obtain accurate results; a fine-pointed hard pencil must be used and the distances *A B* and *C D* should be measured with dividers.

W. T. Heck.

Lafayette, Ind.

A Peculiar Lighting Condition

Concerning the answer to my letter, "A Peculiar Lighting Condition," by Walter G. Mullen, page 70, January 5 number, I will say that he gave the correct *cause* of the trouble, but his reason for the opening of the circuit-breaker is not exactly right.

He says: "If now the switch *A* is opened all of the circuit *C* must pass through the circuit-breaker; this momentary rush of current may be sufficient to trip the same in the manner spoken of." Now, it takes much more than the current of circuit *C* to trip the breaker, as it was installed to carry this current continuously. What really happened is this: Consider the two circuits, *B* and *C*, to be

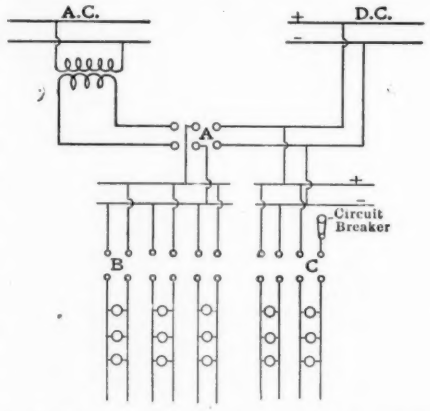


DIAGRAM OF WIRING FOR LIGHTING SYSTEM (REPRODUCED)

each grounded on the negative side, the whole considered as a direct-current system. This gives two negative paths for the current of all the circuits on switch *A*, and not alone that of circuit *B*.

One path is the normal one through the negative pole of switch *A* to the negative bus of the exciter, and the other is through the ground on *B* to the negative side of *C*, through the circuit-breaker to the negative bus.

At the instant switch *A* is opened, a resistance is introduced into the circuit at the negative break, which as the length of the break increases becomes high enough to shunt all of the return current of all of the circuits on switch *A*, through the grounded path, through the circuit-breaker, causing it to open. Since there are a hundred or more lamps on switch *A* the resultant overload on the circuit-breaker is at once apparent.

Of course, this rush of current was of short duration, lasting only while the positive pole of switch *A* was breaking the circuit, yet it was sufficient to trip the circuit-breaker.

Mr. Mullen's explanation of why the lamps of circuit *C* would burn with the circuit-breaker open was entirely correct.

C. L. Greer.

Handley, Tex.

A Motor Trouble

In reply to Mr. Sheehan's puzzle, I would say that if the generators were bought as generators and one used as a motor, it would operate as a differential motor, which was the reason it stalled; and the man had to shift his clutch in order to allow the motor to produce torque.

The reason, of course, for the motor reversing was the series field overcoming the shunt field and reversing the polarity, causing the armature to reverse its direction of rotation. The weak field at the instant of reversal and the heavy armature current would cause the violent sparking; as would the lead of the brushes. If the shunt field had become open for some reason the motor would have acted in the way stated.

L. E. Brown.

Ensley, Ala.

Probable Cause of Air Compressor Explosions

In the issue of January 12, I note a letter from F. W. Holman, with the above title, in which he suggests leaky discharge valves as the "most plausible" explanation of the cause of certain destructive compressed-air pipe explosions. As far as my knowledge extends, the letter does not suggest even a possible cause of such explosions.

The letter says: "Air which had been compressed evidently leaked back into the cylinder, where it became recompressed. This recompression will make it hotter and hotter until it either reaches a point where radiation will take the heat faster than the temperature can rise, or the temperature will rise until the oil catches fire."

In the case under consideration the air was compressed to 17 pounds gage and, with an initial temperature of 60 degrees Fahrenheit, the temperature after compression would be 190 degrees. If the air at this temperature could be recompressed, the final temperature would then be much higher, and if this operation could be repeated many times, the theoretical temperature attained might go as high as the most unbridled imagination could carry it; but no such result could come from leaky discharge valves.

The discharge valves would have to be in very bad condition to leak back 5 per cent. of the air compressed per stroke, and this return leakage into the compres-

sor cylinder would occur during the intake stroke, continuing perhaps, if the leakage was very bad, during a small portion of the compression stroke; not far, because with adiabatic compression, full pressure would be reached when the piston reached the middle. When the piston starts for the intake stroke the air in the clearance space, heated by compression, must first re-expand down to atmospheric pressure and, coincidently with its re-expansion, its temperature will fall entirely back to what it was before the compression began. The air leaking back through the discharge valves also re-expands and its temperature falls correspondingly and, mingling with the incoming air at atmospheric pressure and temperature, the temperature of the whole cannot be raised appreciably by the leakage. This air which has leaked back becomes an inseparable part of the cylinderful and when the mass is compressed and discharged it is carried along together and no portion of it can be isolated and worked back and forth, as assumed, to have its temperature cumulatively augmented.

These attempts to solve the mysteries which still seem to be connected with some of the explosions that occur in connection with compressed air are certainly not to be discouraged. It would seem that the oil rather than the air is the thing to be studied. It is a noticeable thing that the initial explosions seem to occur more frequently in the pipes after the air has left the compressor rather than in the compressor cylinder head, where the temperature may be assumed to be the highest.

Compressed air alone, no matter how hot it may be, cannot possibly explode. The explosion is, of course, due to the ignition of a mixture of air and a volatile constituent of the lubricating oil. This volatile ingredient being present in sufficient quantity, there must still be provided time and opportunity for the mixing to be completed. This operation goes on rapidly, so that the conditions may be ripe for the catastrophe very close to the compressor. With the mixture ready for the explosion, ignition may occur spontaneously if the temperature is sufficient or a spark may be produced by friction and cause the explosion at a lower temperature.

Oil often burns bodily in the compressor cylinder heads and in the receiver without any explosion, receivers and contiguous piping sometimes becoming red hot. This might be going on in some case and provide the means of firing the explosive mixture which might be formed farther along in the pipes.

The obvious deduction is that we should use oils from which the more readily volatile constituents have been distilled, that we should use as little as possible of even the best oil and that, wherever there is a possibility of the used oil accumulating, provision should be made, and availed of, for frequent draining.

FRANK RICHARDS.

New York City.

The Barrus Universal Calorimeter

In the December 29 number there appeared an article entitled, "Barrus Universal Calorimeter," by Charles N. Cross, parts of which I beg to take exception to. Mr. Cross says the steam passes from the sampling pipe directly to the heat gage, and thence through the separator to the atmosphere. The correct arrangement of this instrument is just the reverse, the steam first passing through the separator, where the major portion of the moisture is removed, and then through the heat gage to the atmosphere.

The fundamental principle of the heat gage lies in the fact that when slightly wet steam at high pressure is expanded down to atmosphere, *doing no work*, it is superheated thereby, causing all of its moisture to be boiled out. The latter condition is absolutely essential, since upon it depends the construction of the heat balance and the subsequent calculation of the quality of the steam. The heat gage can only take care of about 4 or 5 per cent. of the moisture in the steam, and if the latter contains more than this amount, it will not be dry at the end of the expansion and consequently the heat balance cannot be written.

If the steam passed from the separator to the condenser, what assurance have we that all its moisture was left behind? On the other hand, by placing the separator before the heat gage, the steam drops all but about 4 per cent. of its moisture in the separator, and is then in a proper condition for the expansion through the heat gage.

CHARLES B. COOKE, JR.

Philadelphia, Penn.

Trouble on Arc Circuit

The transformer in the accompanying illustration evidently had its primary winding connected across a single phase when operating on 2000 volts. The change of line voltage to 11,500 volts necessitated the changing to an auto transformer, with the connections as in the diagram, the secondaries being connected in parallel and the primaries in series, across the phase. As it is now connected, the transformer is good for 10,000 volts (8000-volt secondary and 2000-volt primary) except for the danger of breaking down the insulation of the transformer itself, the primary winding being insulated only for somewhat over 2000 volts. Adding 1500 volts more to make the total 11,500, would certainly increase the tendency to break down the insulation.

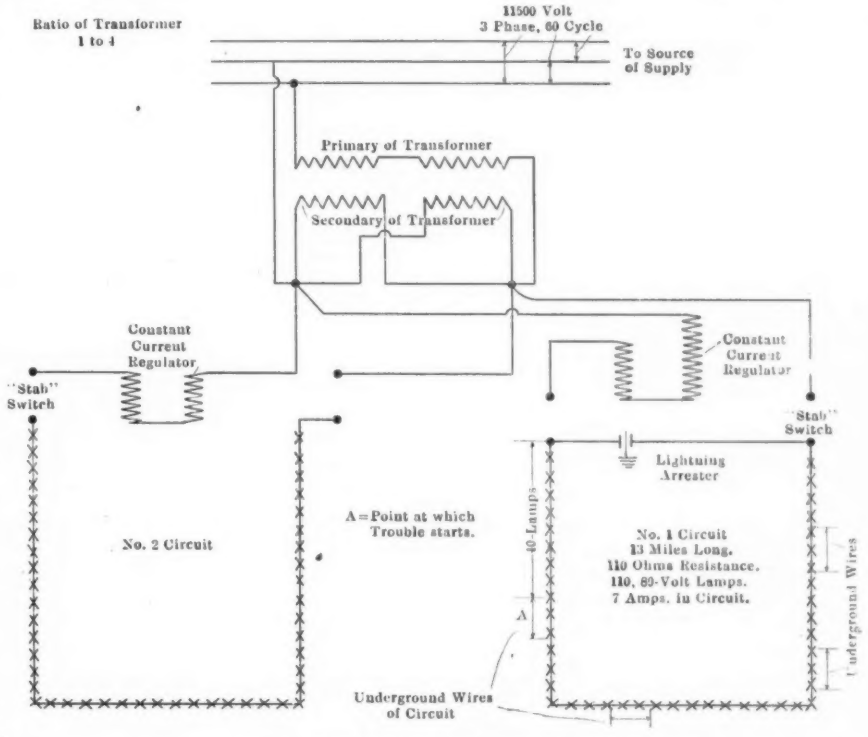


FIG. I. TRANSFORMER AND CIRCUIT CONNECTIONS

As an addition to the diagram in the December issue of POWER AND THE ENGINEER, I have added the lighting arrester in circuit No. 1 for the sake of illustration. In the article by Mr. Minton it was stated that as soon as the "stab" switch was inserted on the regulator side there was a discharge through the light-

ning arrester to ground, also that the aërial line of 40 lamps would burn all right and the ammeter show 7 amperes, but that upon sending the circuit underground trouble started, the rest of the circuit being fed from underground cable having only 4 amperes flowing through it. The regulator acted as if the line was short-circuited.

The trouble should have suggested itself at once. If there was a discharge through the lightning arrester and also trouble was found where the circuit entered the ground, evidently the trouble had to be between the arrester and the underground circuit, showing that the cable had been punctured by the high voltage. The ground wire of the arrester and the other side of the arrester itself had this high potential across it also, causing it to discharge across the gap. There might also have been a possibility of the

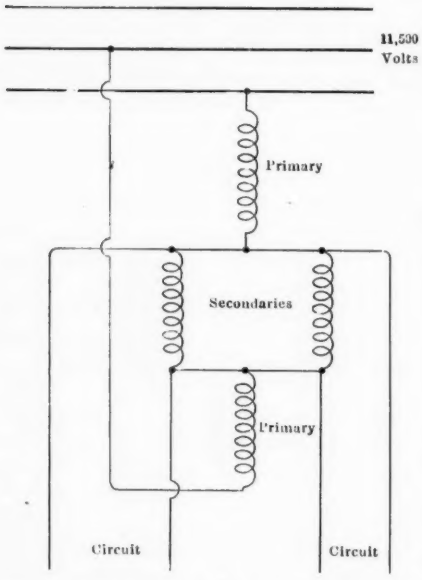


FIG. 2. SECONDARIES IN PARALLEL BETWEEN PRIMARIES

cable being broken down all along in the underground conduit.

The fact of making an insulation test using from 10 to 100 volts and finding one megohm resistance would not guarantee the cable from breaking down when 11,500 volts were sent through it. Finding 500 megohms resistance by such a test would not insure safety from breakdown with this high potential. The correct way would be to test a sample piece of cable directly on 11,500 volts from the conductor to the lead sheath.

The lightning arrester evidently was not built for a circuit of 11,500 volts, the discharge gap being too small to prevent this high-pressure current discharging to ground. In dry air, 11,500 volts will jump an air gap nearly 0.6 inch long and 10,000 volts will readily jump across a ½-inch gap.

The reason for 4 amperes flowing through the rest of the circuit and 7 amperes being indicated by the ammeter was that 3 amperes were escaping to ground, showing again that the underground cable had been punctured. The lamps fed from underground evidently would flicker on account of receiving only about one-half their normal current, which was too small to give enough excitation to the series coils in the lamps that attract the armature holding the upper carbon in suspension. This condition in the lamps would cause them to pick up and drop at short intervals.

The earth return circuit from the underground cable through the lightning arrester would cause the regulator to act as if the line were short-circuited, as it was only regulating 40 lamps, the other 70 lamps having no regulation at all. The trouble would probably disappear if the lightning arrester were removed, thus destroying the return circuit through the earth to the ground wire. When operating on 11,500 volts or even 8000 to 9000 volts, the best and only sure way is to get an equipment of electrical apparatus designed for high voltage, for example a transformer whose primary will stand 12,000 volts across the phase.

In Fig. 2 is given a method by which the insulation strain will be reduced about 1200 volts. In this diagram the secondaries are connected in parallel between the primaries.

EDWARD J McGANN.

Chicago, Ill.

Necessity of Good Pipe Work

The editorial on the necessity of good work in suction piping is very much to the point. If one end of a pipe is under water and the other end attached to a pump in which there are no leaks, and the pump continually loses its water, it is only reasonable to suppose that air leaks in, as the following case will show:

There had been a 12-inch bell-and-spigot joint pipe line, 1400 feet long, laid down a river to a pump located at an elevation of 16 feet above the average level of the water. The pipe joints were supposed to have been properly made, but the pump worked miserably and often had to be stopped and primed after losing its water. The contractor finally agreed to dig up the pipe and ascertain where the trouble was. It became my duty to test every joint as exposed. There was a foot valve at the rims and I adopted the method of stopping the pump and opening a bypass from the delivery to the suction pipe, letting about 30 pounds onto the latter. We left this pressure on for ten minutes, keeping a pan under the joint so as to catch and determine the amount of water that leaked out. In this way we discovered 21 leaks of from 1 to 14 ounces in the ten-minute test, the total of all being 7½ pounds, or 314 pounds per minute. When they were all made tight the pump worked all right.

Most of the leaks were at the bottom of the joint where the lead meets, and was partially cooled, after flowing down the sides of the joint, and possibly due to the fact that the joint does not always get as good calking there as on the more accessible top and sides.

The difference between good and poor work is shown in the fact that we have in daily use a 6-inch galvanized wrought-iron pipe, 700 feet long, with a lift of 24 feet, which is perfectly tight and has been for thirty-one years.

PETER H. BULLOCK.

Concord Junction, Mass.

Firing Stationary Boilers

The remarks on firing stationary boilers, by J. F. Bradley, in the January 5 number, in which he quotes Mr. Wadleigh as saying: "The fireman should know that the place to shut off or regulate draft is at the stack damper and not by the ashpit doors, the latter being for the purpose of *regulating the air supply,*" arouses my curiosity as to how Mr. Wadleigh differentiates between regulating the draft and regulating the air supply.

Mr. Bradley's theory that smoky coal will clog the tubes quicker with the damper partly closed than with the ashpit doors partly closed is true. The fact that it took him a long time to figure out the why and wherefore thereof is no indication that he is slow at "figuring," but that the question of properly operating a steam boiler is one that bothers a whole lot of people.

Regulating draft is primarily a question of fuel economy; secondarily, a question of load variation. I assume that we are dealing with hand-fired boilers, in which case the fuel is fed intermittently, which fact necessitates the intermittent admission of air to the fire.

In my judgment, the ashpit doors should be left wide open while the boiler is in service, and *after* each fresh firing, the stack damper should be opened wide until the gases have been consumed, when the damper should be partially closed the correct amount to take care of whatever load happens to be on the boiler.

After the volatile gases in the coal have been consumed, the passage of excessive air through the furnace results in loss of heat by carrying it up the chimney.

The ideal draft regulation provides for full draft after every fresh charge of fuel, a gradual diminution, according to the load on the boiler, and finally cutting down the draft to the last degree permissible. Such regulation will not increase the deposit of soot in the tubes for the reason that combustion will be more complete and less soot will be made.

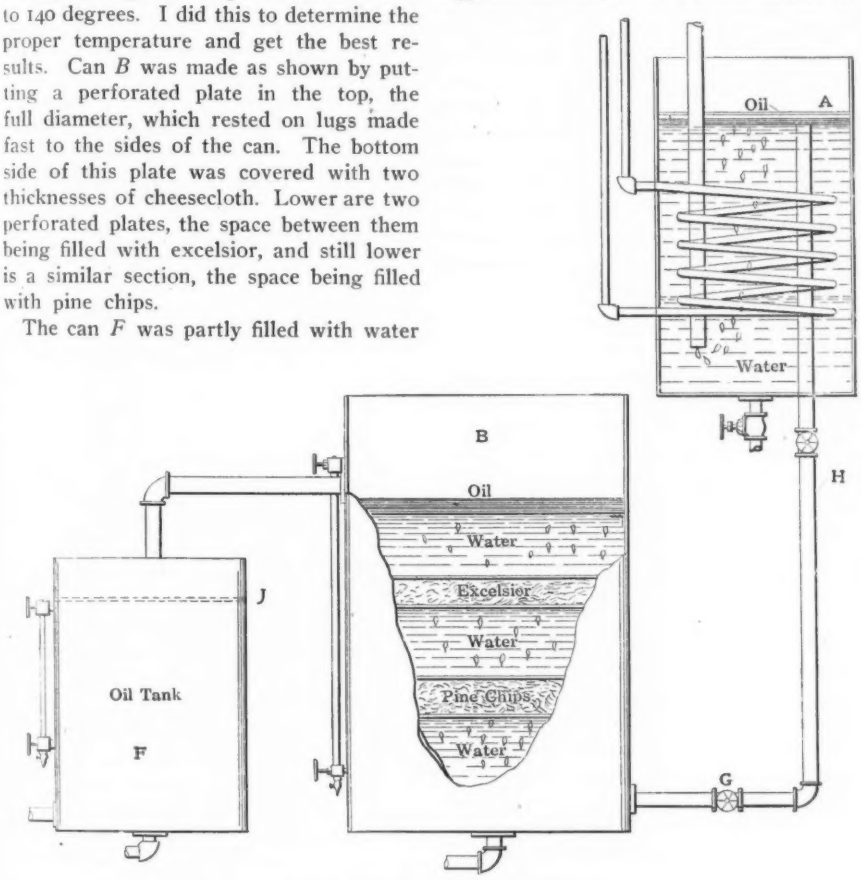
E. G. TILDEN.

Downers Grove, Ill.

Filtering Oil

When I had charge of a producer-gas plant and gas engines it at first seemed impossible to get rid of the carbon in the oil that drained from the engine bearings. However, I finally took three cast-off filters of different sizes, took out the filtering arrangements and connected them as shown in the sketch. I put a ⅛-inch brass coil in can *A* and connected it to the exhaust pipe of the water pump. This gave me just about steam enough to keep the oil warm. I also connected a live-steam pipe to it, so I could shut off the exhaust steam and turn on the live steam, raising the temperature of the oil to 140 degrees. I did this to determine the proper temperature and get the best results. Can *B* was made as shown by putting a perforated plate in the top, the full diameter, which rested on lugs made fast to the sides of the can. The bottom side of this plate was covered with two thicknesses of cheesecloth. Lower are two perforated plates, the space between them being filled with excelsior, and still lower is a similar section, the space being filled with pine chips.

The can *F* was partly filled with water



HOMEMADE OIL SEPARATOR

before putting oil in it. I found I got the best results by passing the oil through the pipe *G* and up through all the different parts of the filter.

The operation of the filter is as follows: The oil descends from the engine bearings through the pipe, passing down to within 8 inches of the bottom of the can *A*, rising up around the heated coil to the end of the pipe *H*, and flowing down to the base of can *B*, up through the water, pine chips, excelsior and cheesecloth and out through the overflow to the can *F*. It then passes down through cheesecloth at *J* and is pumped back to the elevated tank. This did the trick with a temperature of 90 degrees Fahrenheit.

Blow-down pipes are placed in the bottom of each can, and all the dirt that collects can be blown off. The pine chips are renewed once a week and the steam hose played on them to cleanse of dirt, etc.

W. A. Dow.

Cambridge, Mass.

Hygrometry

On page 63 of the January 5 number, W. V. Treeby attempts to criticize a statement made by J. H. Hart in an article on "Hygrometry," which appeared in a recent issue. It would appear that Mr. Treeby has an entirely wrong idea as to the meaning of the word saturated as applied to steam. If he will brush the cobwebs off of his physics and consult some handbook on steam, he will find that saturated water vapor or steam does not mean that the vapor or steam is "saturated with heat units."

When steam and water are present in the same vessel, and there is no tendency for the water to change into steam, or the steam into water, except as heat is added or taken away, the water and steam are then said to be in thermal equilibrium. When steam is thus in equilibrium in contact with water, it is said to be saturated. When there is no moisture or water in the liquid condition suspended in or mixed with the vapor, but it is still in the saturated condition as determined by its pressure, temperature and volume, it is called dry and saturated. When there is moisture or water suspended in or mixed with the vapor, the steam is said to be "moist" or "wet." In such cases the steam or vapor part of the mixture must itself be in the saturated condition as defined above, so that wet steam is simply a mixture of saturated water vapor and liquid water.

John French.

Brooklyn, N. Y.

Boiler Setting

The boiler setting illustrated on page 71 of the January 5 number has so many bad fcatures, without any good ones that I have been able to see, that I doubt very much if any set of conditions would warrant its use.

If such a setting could be maintained in good order, which is obviously impossible, we are still confronted with the fact that the soot-blower door is between the fire and the boiler, and cold air would leak through the cracks around the soot doors and mix with the furnace gases before they pass into the boiler tubes.

Aside from this, the soot door produces a means of air leakage in the brickwork and removes a section of brickwork right where a refractory material is most needed for the purpose of raising the temperature of the gases to the igniting point before passing into the tubes. Add to this the loss due to radiation through the thin cast-iron soot door, and it is very easy to account for the loss of a very respectable part of the fuel at this one point.

Turning to the dividing wall midway of the boiler, in practice it would be found impossible to maintain a tight joint between the top of this wall and the shell of the boiler so that instead of the gases following the path that the designer expected, some would "short-circuit" over the top of the wall directly to the chimney without having passed through the boiler at all.

The worst feature of this setting is the absence of a roomy space between the fire and the boiler, where the gases, when distilled from fresh fuel, will have a chance not only to expand and mix with the oxygen of the air coming through from the ashpit, but must flow by or through a mass of incandescent firebrick, thereby raising the temperature of the gases to the igniting point before entering the tubes.

If we are dealing with a working gage pressure of, say, 150 pounds, the temperature of the water in the boiler will be, say, 338 degrees Fahrenheit, while with the ordinary setting the brick furnace and combustion-chamber lining can be kept at from 1600 to 2000 degrees Fahrenheit by properly manipulating the flue damper.

This setting provides a "roomy space" at the rear, but the furnace gases must pass through the comparatively cold boiler

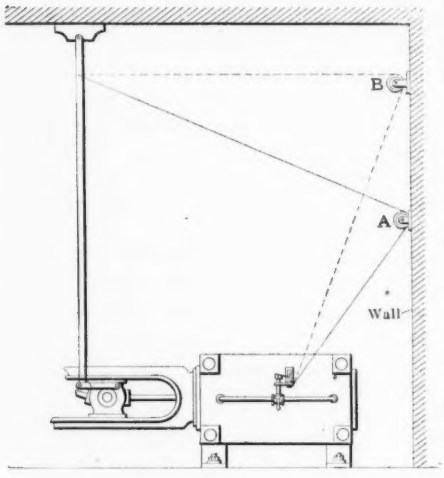
tubes before reaching it, which necessarily lowers the temperature to such an extent that any unburnt portion of the gases must be lost.

E. G. TILDEN.

Downers Grove, Ill.

Faulty Indicator Reducing Motion

When I was the master mechanic of a certain company in a small town, the manager and chief engineer of the town lighting plant brought several indicator cards to my office and asked me if I could see anything wrong with them. After studying them, I told him that they were very good, and, in fact, I would consider the valve adjustment all right. The cards were taken from a small Corliss engine that they had just installed to drive an alternator. The engine was second-hand, but seemed all right except that the belt flopped badly. The next day I went to the plant and immediately discovered the



REDUCING-MOTION RIG

engineer's error. He had made a reducing motion out of a piece of 1x4-inch pine stick, pivoted to a block fastened to the ceiling, the other end linked to a pin screwed into the crosshead.

The pendulum hung vertically when the crosshead was in the center of its travel. The link was so connected to the pin in the lower end of the pendulum that it swung an equal distance above and below the center line of travel of the pin in the crosshead. In locating his carrying pulley he had placed it as high as he could reach by standing on the cylinder, which brought it to about the position as shown at *A*, in the illustration, which caused a very misleading diagram to be produced.

We raised the carrying pulley to the position shown at *B*, so that the cord (see dotted line) would lead from the pendulum at a right angle when the pendulum was in the center of its travel. When the valves had been readjusted the belt ran without flopping.

V. R. HUGHES.

Denver, Colo.

Steam Condensing Plant

G. A. Orrok, in his letter in the December 22 number, on surface condensers, mentions that careful experimenters are reported to have obtained rates of condensation in steam surface condensers as high as 40 or 50 pounds per square foot. It may be interesting to readers to know that in the experiments at the Hartlepool engine works on a small contraflo condenser, designed for use as a winch condenser on board ship, I obtained rates of condensation up to 80 pounds per square foot, and have no reason to believe that I reached the limiting rate of condensation. This condenser had 100 square feet of cooling surface, and the steam was condensed at atmospheric pressure, the air blowing off through a relief valve and no air pump employed. In the tests in which 80 pounds of steam were condensed per square foot of surface, the circulating water entered at 39 degrees Fahrenheit and made its exit at 195 degrees Fahrenheit. The tubes were ⅝ inch external diameter and the velocity of the water through them was 4.6 feet per second.

I believe that with a higher velocity of water a greater rate of steam condensation could have been obtained. It should be noted, however, that the steam was at atmospheric pressure. Steam under a high vacuum is much less dense and, therefore, in a much less favorable condition for a high condensation rate.

With reference to the statement that the heat transmission in surface condensers is proportional to the cube root of the velocity of the circulating water through the tubes, I believe that the heat transmission varies sometimes as the cube root, sometimes as the square root, and sometimes almost directly as the velocity of the water. In fact, the law connecting the transmission of heat with the velocity of the water is of a somewhat complicated nature, but the subject is too big to enter upon on the present occasion.

In Charles L. Hubbard's article on condensers, in the same number, he refers to the relative quantities of condensing water required by a parallel-flow jet condenser, such as that illustrated in his Fig. 5 (reproduced here) and by a surface condenser, and states that the water required by the former is less than that required by the latter. I think that this statement is somewhat misleading.

Assume that the vacuum is 27 inches of mercury (with barometer at 30 inches) and that the condensing water is received at 65 degrees Fahrenheit. The temperature of saturated steam at 27 inches vacuum is 115 degrees Fahrenheit, but as air is always (under practical working conditions) present in the steam the discharge temperature of condensing water and water of condensation in a condenser such as that shown in his Fig. 5 must be considerably below 115 degrees—say 105 degrees. The latent heat of steam at 27 inches of vacuum is 1034 B.t.u., so that the heat withdrawn from the steam is 1044 B.t.u.

Let

W = Pounds of steam per hour,

Q = Pounds of condensing water per hour,

t = Temperature of discharge of condensed steam and condensing water.

Then, as the heat gained by the water must equal the heat lost by the steam,

$$Q \times (105 - 65) = 1044\,W$$

and therefore

$$Q = \frac{1044\,W}{105 - 65} = 26$$

pounds of condensing water.

Surface condensers are variously constructed and worked, and the results obtained with them vary accordingly. The best results as regards consumption of

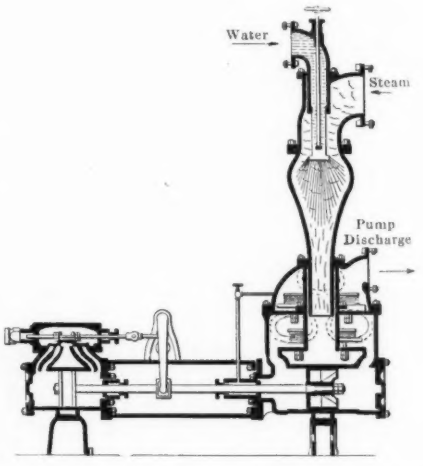


FIG. 5. A COMMON FORM OF JET CONDENSER (REPRODUCED)

condensing water are obtained with surface condensers of the countercurrent type, that is, in condensers in which the general direction of flow of the circulating water is opposite to that of the steam. The exit temperature of the circulating water in such condensers may be anything between its inlet temperature and the inlet temperature of the steam, depending on the design of the condenser and the quantity of water employed.

Professor Weighton in tests on an experimental contraflo condenser at Armstrong College, Newcastle-on-Tyne, England, obtained exit-circulating water temperatures practically the same as the inlet temperatures of the steam and, in fact, slightly in excess of the temperatures corresponding to the vacuum maintained. It is all a question of design and proportions.

Hence with a 27-inch vacuum and circulating water at 65 degrees Fahrenheit it would be quite possible (although it might

not pay in practice) to have an exit-circulating water temperature of 112 degrees Fahrenheit.

The heat withdrawn from the steam would then be 1037, and we would have

$$Q = \frac{1037\ W}{112 - 65} = 22$$

pounds of condensing water, considerably less water therefore being required than in the case of the jet condenser.

As aforesaid, a design of surface condenser to give this result might not pay; but, in steam-turbine installations, where the temperature of the circulating water is in the neighborhood of 80 to 85 degrees Fahrenheit, as is common when cooling towers are employed, it usually pays to arrange the surface condensers to use less water than would be possible with a jet condenser of the nature of that shown in Fig. 5 of Mr. Hubbard's article.

Mr. Hubbard referred to cooling towers and mentioned that with the best forms it was claimed that the water could be reduced in temperature 40 or 50 degrees. With the wooden natural-draft towers, which may be said to represent standard practice in turbine power stations in Great Britain, the water is usually cooled to about 80 to 85 degrees Fahrenheit, the inlet temperature of the water to the tower affecting its exit temperature to a comparatively small degree.

R. M. Neilson.

Glasgow, Scotland.

Valve Problem

The answers to the valve problem, on page 59 of the January 5 number, are interesting but very conflicting. For instance, G. A. Glick and B. A. Snow both claim that 358 pounds per square inch would be necessary to raise the valve against 100 pounds pressure per square inch on top, whereas J. C. Hawkins says that 100.9 pounds pressure per square inch will be sufficient. I agree with him, as under practical working conditions it is only necessary to consider the area that actually covers the openings, and not the total area of the valve disk.

I know of large pumping engines having valves similar to the one I illustrated on page 970 of the December 8, 1908, number, only much larger, and I should judge that the actual valve passages were not more than half the area of the valve disk, yet I am certain that the pressures in the pumps were never more than a few pounds above that in the lines, whereas according to Mr. Snow and Mr. Glick they ought to be about double.

Under practical conditions I do not believe that any valve seats so closely as actually to touch surface to surface all over, which it would have to in order to fulfil the conditions assumed by Messrs. Glick and Snow. The surfaces only touch in a few places, the remainder being separated by a film of liquid or gas—whichever may be used—so thin that the cohesion and surface friction is enough to resist the actual flow, but as the difference in pressure on each side of the valve becomes less and less, the elasticity of the material where the surfaces actually touch is compressed, thus slightly increasing the thickness of the film and allowing the pressure of the liquid, or gas, to be transmitted over a greater area until, as the pressures become equal, and the under side of the valve is receiving the full pressure, a slight increase will lift the valve. I believe it is possible to surface a valve and its seat so accurately that the pressures will have to be proportional to the top and bottom areas before the valve will start.

George P. Pearce.

Exeter, N. H.

A Homemade Condenser

In the December 29 number, M. D. Caspar asks for advice for making a condenser for the returns from an exhaust-steam heating system.

The only device that he needs, as far as I can see, is an ordinary low-pressure pump connected direct to the return main and large enough to handle the volume of water that may accumulate. This pump may discharge into a heater, or hotwell, etc., as conditions warrant. A pump will handle the water as it collects, provided the pump is placed at a lower level than the system, so that the water will flow to it by gravity.

Charles A. Crytser.

Windber, Penn.

Coal Consumption

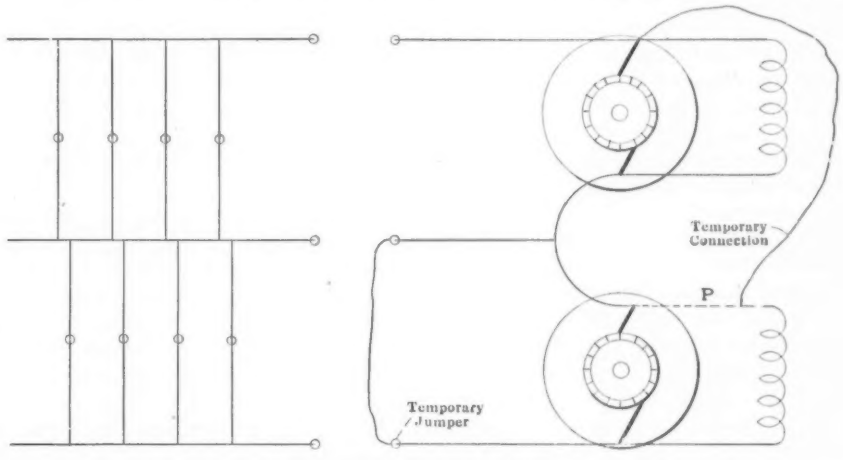
I was much interested in the article on coal consumption per kilowatt-hour by Mr. Dow, in the December 29 number, on page 1088, in which he notes the difference between two plants, one containing engines fitted with a long-range cutoff and the other with engines having only one eccentric. His figure of 2.35 pounds per kilowatt-hour is the lowest I have ever heard of. I fail to see where the type of valve gear would make the difference noted. The only advantage I see in the long-range cutoff is the ability to handle sudden overloads. If the engines were running at their most economical load, which they must be doing to make a kilowatt-hour on the given quantity of coal, the single-eccentric engine would cut off just the same as the double-eccentric engine, and the only difference indicator diagrams might show would be in the compression curves, and they would probably be the same. I am inclined to believe the difference in the coal consumption can be traced back to some other feature of the plant.

Edward H. Lane.

Kansas City, Mo.

Reversal of Polarity

In the December 22 number W. S. Young asks for information as to the cause for reversal of polarity of one of his machines on a three-wire system. Without knowing exactly what method was used in stopping the machines, it would be hard to tell the real cause. If there were any motors on that side of the system, it might possibly have been caused by a "back kick" of one of them at the time of shutting down.



METHOD OF RIGHTING A REVERSED MACHINE ON A THREE-WIRE SYSTEM

I once had charge of a three-wire system using the same type of machines, one of which frequently became reversed without any apparent cause.

A method of righting a reversed machine on a three-wire system, requiring only a few minutes' time and no change of connections, except temporarily changing one field wire, is shown in the accompanying diagram.

To operate, raise the brushes from the commutator of the reversed machine, disconnect the shunt field wire from the *neutral* side and connect it temporarily to the outside brush of the other machine. Make a "jumper" across the brush leads of the reversed machine as

shown, and brings the voltage up on the other machine. Then shut down and remove the "jumper" connection and the temporary field connection, leaving it connected to the neutral winding in the usual way, as shown by the dotted lines at *P*. Then put down the brushes and the polarity will be correct. Either machine can be righted in the same way, but always be careful to have the brushes raised, and to remove the jumper before starting up the machine which has been reversed.

S. KIRLIN.

Dallas, Tex.

An Air-cooled Condensing Plant

In the twelve years that I have read POWER there have been many valuable articles in its columns, treating on condensing plants, their installation, cost of operation, maintenance, etc., but I have failed to read of any that cost practically nothing to install and nothing to operate.

Some years ago in the oilfields of western Pennsylvania all wells were pumped by steam power, gas engines not being in general use at that time. In one particular locality the only water-pumping station was abandoned about this time as a nonpaying investment. As well water was unfit for boiler use, the use of the surface condenser and rainwater were the only means of obtaining the necessary water for operation.

The condenser was made of old 6-inch pipe that had outlived its usefulness in the oil wells. It was laid out on the ground in such a way that the water of condensation would drain back to a barrel sunk in the ground under the pump which was attached to the crosshead of the engine. The amount of pipe required depended on the size of engine and the load it was carrying. Usually 600 to 800 feet were sufficient for each 20-horsepower engine.

The exhaust steam of the engines was expelled into this pipe, where it would be condensed and returned to the pump; in some instances the loss was so small that from six to ten barrels of makeup water was sufficient for 40 horsepower of engines each twenty-four hours. The makeup water was supplied from storage tanks in which was caught rainwater from the roofs.

It might be said that plants were operated twenty-four hours a day, except Sundays, by one man who worked on the lease in daytime and went to his home at night. The boiler was equipped with a gas- and steam-pressure regulator, combined with a low-water alarm which blew a large whistle, calling the pumper from his slumbers, in case the water got low in the boiler. There were several plants operated in this manner for a number of years without any serious accidents and no one looked upon it as remarkable.

J. A. MAWHINNEY.

Franklin, Penn.

Testing Watt-hour Meters

In the issue of January 5 I note an article by O. F. Dubruiel on "Testing and Adjusting Watt-hour Meters." A power station not already equipped with stop watches, voltmeters and indicating wattmeters would do much better to buy a portable standard integrating watt-hour meter, otherwise known as a rotating

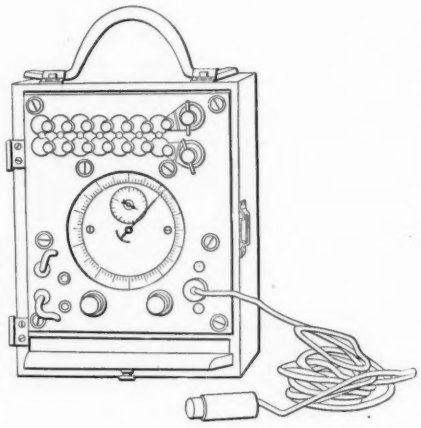


FIG. 1

standard, for from $60 to $65. These are now made by all the large companies and are very much simpler and easier to use. No voltmeter or stop watch is required, as any variation of voltage or load affecting one meter affects the other in the same way.

The meter has the appearance shown in Fig. 1, and can be changed from 110 to 220 volts by simply changing the small leads shown at the lower left-hand corner of the faceplate. The meter is stopped and started by means of a push switch at the end of the cord and the dial registers the number of revolutions of the standard meter; by counting the number of revolutions of the meter under test, clos-

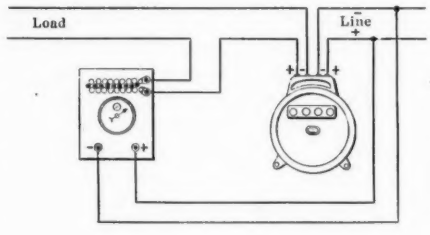


FIG. 2

ing the switch on starting and opening it on stopping, a direct comparison is obtained and the percentage of error may be easily calculated. One man can easily test several meters a day. Better still, it is quite practical with this instrument to test a meter on the customer's premises.

The connections are very simple, as shown by Fig. 2, and a table accompanies each meter giving percentages from 6 per cent. slow to 6 per cent. fast for all standard makes of watt-hour meter. The instrument is adjusted for different current capacities by means of the plugs at the top of the face plate.

JOSEPH B. CRANE.

Broadalbin, N. Y.

Engine Foundations

There can be no hard-and-fast rule for building foundations of any character, especially for engine work. In best practice it is found that foundations for this class of work should be governed by the weight of the machinery placed on them. A safe construction for a foundation is to know the weight of the machinery, and build the foundation one-half heavier than the engine, i.e., if the engine weighs 150,000 pounds the foundation should weigh 225,000 pounds. This applies to small installations, as well as to large and heavy work.

Every heavy foundation should have a base which separates it from the foundation proper. It is better to have a foundation which will have some "give and come" to the action of the engine. The slight movement if taken up on an earth or sand bottom, would in time wear it away, especially where water soaks in alongside, and the settling is liable to make the engine work out of line.

Where concrete floors are used in engine rooms there should be a space of about ⅛ inch between the floor and foundation to permit the vibration of the foundation and not to impart the jar to the floor.

The writer recalls where the floor for an engine was waterproofed at great expense, the earth being of salt-marsh formation, where test piles with a 1500-pound hammer "keep going" after 85 feet of driving. Thirty-foot piles were driven under the engine and the waterproofing placed on the top. When the erecting engineer came to install his work he found only 18 inches between the floor line and top of the waterproofing. The drawings called for a foundation 3 feet 6 inches in hight, or extending 24 inches above the floor line. The "young man" followed his instructions and the top of the engine bed was placed 36 inches above the floor level.

This engine has been in use about 12 years and is satisfactory in every way, except the hight of the engine bed above the floor. Since then there have been two engines of fully as large capacity placed in the same room, with the foundations spreading 14 inches outside of the engine bed in every direction, and only 12 inches above the floor line. These engines have also proved satisfactory.

FRANCIS H. BOYER.

Somerville, Mass.

Some Useful Lessons in Limewater

A Simple Method of Remembering What Has Been Told in Previous Lessons; Softening Temporary-hardness Water; Some Chemical Shorthand

BY CHARLES S. PALMER

The only sensible way for common workaday folk to learn the value of a thing is to use it; and so we will try to put this limewater to work at once. We have found out that the plain lime carbonate is insoluble, and that is what makes most of the soft scale from temporary-hardness water. Then what we want to aim at is to get this plain lime carbonate out of the water before it goes into the boiler. Now you have found out that you can go to the plain carbonate of lime in two ways: One is by starting with limewater, and adding carbonic acid (from the breath, from the gases of burning coal, from bottled "fizz," or from acid and marble or soda); the other way is by taking out the extra carbonic acid from the extra, or double, or bicarbonate of lime (temporary-hardness water) by heating it, when the extra carbonic acid goes off, and down comes the plain carbonate of lime.

You must get these two ways fixed in mind; and one good thing to do is for you to stop right here and set down this simple formula. Don't be satisfied with merely looking at this once, but write it for yourself several times, until it is stamped into your memory so that you can see it in your mind's eye any time. Here it is:

Lime-water. Soluble. <—> *Plain Lime Carbonate. Insoluble.* <—> *Extra Carbonate of Lime. Soluble.*

The double-headed arrows mean that you can go from one substance to another; and if you stop to think of what you have done, you will see that this is a kind of shorthand reminder of it all. You did go from limewater to plain carbonate, by adding some carbonic acid; and you passed from this to the extra carbonate of lime, by adding more carbonic acid; then you came back from the extra carbonate of lime to the plain carbonate by taking out this extra carbonic acid. And this last step is what that heater is for. So you see how handy this formula is.

The double arrows tell, even, much more than can be told here. Thus, briefly, the plain carbonate of lime, or limestone, is first changed into lime by burning in limekilns; and you can imitate that by burning some marble in the front part of your furnace. About all the other steps indicated by the arrows have been shown in the various tests that you have made or are making.

Now you begin to get the fundamental chemical notion that "salts," such as plain carbonate of lime and extra carbonate of lime, are made up of acids and bases. In this case, the lime is a base. There are strong acids and there are weak acids; and, also, there are strong bases and there are weak bases. When a base is soluble in water, it will turn litmus blue; and such water-soluble bases are called alkalies; and so it comes that limewater is an alkaline base. Some bases, like iron rust, are good bases, and can neutralize acids, forming "salts;" but iron rust is not very soluble in water, and so it is not alkaline, like the soap, the ammonia water and the soda. (This "soda," by the way, is really a "salt" made up of carbonic acid and the metal sodium; but the sodium is so much more active as a base than the carbonic acid is active as an acid that the soda, as a whole, acts like an alkali. But we will study that more carefully later.) Now you begin to get this fundamental notion of the base part and the acid part of every "salt." You begin to see that you can get, by mixing the base and the acid in various quantities, "salts" which may be even in base and acid, i.e., plain salts; or "salts" with more of the acid, as in the case of the extra carbonate of lime; and, in other cases, even "basic salts" with more of the base than acid in them. But this is the point that we are aiming at. You have one way to soften temporary-hardness water by driving off the extra carbonic acid with heat. The formula reminds you of that step; but why not work the same scheme in another way? Why not get some handy base to mix with this soluble extra carbonate of lime, and bring it back to the plain carbonate? That is another way to soften temporary-hardness water.

Softening Temporary-hardness Water

It has perhaps occurred to you that if the lime in water is a base, and if the soluble lime salt, lime bicarbonate, is an extra carbonate, why not mix some of the limewater with this extra carbonate and get the insoluble simple carbonate? So we make some more of the artificial temporary-hardness water by blowing through the plain limewater until the white sediment that first comes is redissolved; and, as before, we filter it to get as clear a solution as possible. Now we mix the two; the plain limewater and the solution of extra or bicarbonate of lime which you have just made. You have figured that as the limewater has some base, and as the bicarbonate of lime has extra acid, you ought to get the neutral white sediment down; and that is just what happens.

Down it comes, or, rather, it comes out of solution, but it doesn't settle with any surprising quickness. However, you have got it out of solution; and that is something to be thankful for. If you give it time to settle, plain limewater would take the lime sediment out of temporary-hardness water just as well as heating it would, because both methods change the extra or bicarbonate of lime to the neutral or insoluble carbonate. But in the solution you have used you worked with water of the same strength, or having the same relative amounts of lime and bicarbonate, while the water that you would run across in practice will run all the way from only a little carbonate-of-lime hardness to nearly as much as equal volumes of limewater solution and extra-carbonate solution will throw down. You want to stop and study this process—by the way, the books call this Clark's process for softening temporary-hardness water—and you will see that it amounts to getting the average of plain carbonate of lime by mixing the base, lime, with the extra-acid salt of lime. Indeed, you can get a kind of simple chemical equation by the following formula:

Lime-water. Soluble. + *Extra Carbonate of Lime. Soluble.* = *Plain Carbonate. Insoluble.*

The books write this same process by the use of some curious letters and figures, and pretty soon we will begin to get acquainted with some of those things, for they are only so many helps to thinking and doing. One thing that you want to remember is this: That, within all reasonable limits, you can do anything down in the dusty boiler room that anyone can do in the best laboratory in the world. This is no joke, for Mother Nature is right at your elbow bossing the action of your chemicals as carefully as though you were a member of the Royal Chemical Society; and whatever can happen in any first-class laboratory in Paris, Berlin, London, or New York can happen as easily right in your boiler room. The laws of chemical union follow us about everywhere. You know this because you have seen the laws of combustion not only in your boiler room or in large conflagrations, but you have seen them follow the

skyrocket up into the air, follow it in its glorious explosion, and follow each of the glittering sparks as they float down through the air. So no one has any monopoly on chemical action, nor on brains, either.

But to get back to Clark's process of softening temporary-hardness water. You can see that it would be no end of bother to make even a barrel of filtered limewater; and a useless bother, if we could put quite a large quantity of lime in a small bulk of water and make it do its work with the large volumes of water which have to go into the boiler. If you go back to the lime from that barrel, you will remember that it takes several hundred parts of water to dissolve one part of lime as you filtered it clear. But you will note that when you put several lumps of lime into water, it crumbles and can be stirred up to a milk, a thin, porridge-like liquid. This is called "milk of lime," and it is a mixture or "emulsion" of lime in limewater. You can see that very little of this milk of lime will do the work of a whole lot of filtered limewater, in the neutralizing of the extra carbonate of lime, and bringing it back to the insoluble plain carbonate of lime. Thus, you see that you could use this way to soften temporary-hardness water.

But it is best to know how much of the milk of lime to use with any special water, and with the same water at different times of the year, and you can learn all of this by keeping along with these lessons. You will find that the man who learns to figure the problems that he runs up against as a rule comes out ahead in the great game of life; while the man who dodges figures, whether in the office or in the boiler room, is simply letting somebody else do his rightful work and get his rightful pay. So we will gradually get at some of these figures, and the ways of calculating the milk of lime needed to soften any grade of water.

Some Chemical Shorthand

And, now, toward the end of this shift, just a word about some chemical shorthand that you will find very handy, if you don't try to choke yourself with too big a mouthful at the start. Just take it by bits. You know how to read and write; and you would be ashamed not to; and in the same way, you want to know how to read and write chemistry; not all that can be written—and much of that does not concern you at all—only the common elements. Now what is your name? Smith? Well, S is your initial, isn't it, and don't you use it for short? Good, then S stands for Smith, the unit man who walks under your hat. So in the same way, C stands for carbon, the unit chemical that is in coal; O stands for oxygen, the unit thing in the air that helps your coal to burn; Ca stands for the metal calcium that is at the bottom of your friend, lime; and H stands for hydrogen, which is found in water, in wood, in soft coal, and many other things. Thus far we have studied limewater, with a glance at carbonic acid; but there is the burning of the coal that must come as soon as we have got well along with this question of water supply, and you will find it very handy to use some few of these initials of the chemical units or elements. For you will not only want to use this chemical shorthand in a simple way in these boiler-room studies, but you will outgrow this simple material one of these days; you will get gloriously mad with yourself, and go to reading better and bigger books, and you will find that all of them use this chemical shorthand, so we may just as well begin to get acquainted with it right here and now.

Then C stands for carbon; Ca for calcium, the metal at the back of what you call lime in general, with all of its compounds; O stands for oxygen, the thing in the air that helps burning; and H stands for hydrogen, a metallic gas—that is straight—a metallic gas, and yet cousin to carbon and coal in the way it burns. There is a lot of hydrogen burning under your boiler, and there is hydrogen in all water, and, of course, in all water compounds. We will not hurry, for it takes time to get things in the head so they will be right and stay there. But, if you are patient with yourself, you will learn these and many more, so you can handle them easily and surely. But the only way really to learn about a thing is to use it, from the start. Let us use these shorthand symbols for the elements that we have run across in this limewater lesson.

Now, lime is the rust or oxide of a metal, and we tell that long story in this short formula, CaO. That is lime, the stuff in the barrel that you are sitting on. The formula says that lime is made up of calcium and oxygen, and every time that you see or use this formula, you are reminded that lime, common quicklime, is made up of calcium and oxygen. You don't have to remember it; it remembers itself, and reminds you all about its own makeup. So, then, lime is an oxide of the metal calcium; and yet we never lose any flesh worrying over calcium itself. Not that calcium may not have a whole lot of most interesting information of its own. Thus, if you should get some of the metal (and it is a trick to get it), you would see a white metal—very light weight for a metal, about twice as heavy as water, while common iron is nearly eight times as heavy as water, copper nearly nine, and lead more than eleven times as heavy as water.

This metal, calcium, cannot be kept lying around in any old way, as the common metals can; for, if left in the air, it rusts itself away and changes to lime, and you know that lime cannot be kept long, for it takes on water and other things from the air and gets "air-slacked." This metal calcium melts at a higher temperature than lead, but it can be cut, drawn and rolled; in short, it has the "metallic" action in general. But this metal never shows its head in the metallic form, unless one gets after it with special plans and methods; and all that does not bother us a bit, because it is not the metal as metal that we are concerned with, but some few of its compounds that have had the nerve to make your water hard in several facetious ways. It is the compounds of this metal, calcium, which we are studying: Lime, the oxide, CaO; the simple carbonate, $CaCO_3$; the bicarbonate, $Ca(HCO_3)_2$; and the like, that we want to get at, for we have only begun to open up the mystery of that barrel of lime.

But to sum up what we have touched on thus far, there are two ways of softening temporary-hardness water: One is by driving off the extra carbonic acid by warming, as in your heater, and the other by driving down the extra carbonic acid by an extra base as lime; and in both cases we get the plain carbonate of lime thrown down. Of course, we must have the right tank for the water to settle out clear, in either case; but we have laid the fundamentals, and now it is up to you to study what kind of heater or settling tanks you are using, and whether they are suited to your work in design, in material, in size, in the piping and connections, and the like. But you should try this second way of softening temporary-hardness water, by adding a few drops of the limewater emulsion, milk of lime, to some of the temporary-hardness water, say a teaspoonful of the milk of lime to a pint of the hard water, with quick stirring, and then allow time to settle. Each part of this simple experiment will tell you something that will relate to the action of the water softener that you may have in the boiler room. Thus it may take some time for the plain carbonate to settle out, and that may suggest why your settler may not always work as it should.

Some Simple Tests

There is one other thing that you will want to do before you close this shift; that is the way to tell, by a simple test or two, whether you may have temporary-hardness or permanent-hardness water. When you add some of the milk of lime to the water, with good stirring, and then add a teaspoonful of nitric acid, if the whole solution clears up, you have only temporary-hardness water. But if you take some of the solution of barium chloride (or nitrate), and add a few drops to a sample of water, you may get a white cloudiness; now add a teaspoonful of hydrochloric acid or of nitric acid to this, with shaking or stirring, and if it clears up, the water is of the temporary-hardness, or carbonate kind; but if the cloudiness of the water persists after adding the nitric acid or the hydrochloric acid, you have some permanent-hardness water, of the sulphate kind, and that is harder to

deal with. But even in that case, it will pay you to know what the trouble is, for sometimes you can conquer it, and at reasonable cost.

The idea that you want to carry with you is this: Temporary-hardness waters have to do mainly with carbonates of lime, while permanent-hardness waters have to do with sulphate of lime. Sulphate of lime is a compound of lime with sulphuric acid, the heavy oil of vitriol that you have seen about shops for cutting the scale off of forgings. There is one thing, too, that you want to remember about this sulphuric acid: It has a great liking for water; therefore, when you dilute the acid, always *pour the acid into the water* (never the water into the acid). The solution of sulphuric acid that came with your outfit is probably already diluted with water; that is part of the chemical story of water, which runs right along with the story of lime.

Screens for Pump Suctions

By Alonzo G. Collins.

In designing the arrangements for a supply of condensing water for the steam engines of an electric-light station some years ago, it was considered advisable to place the fine screen for intercepting the smaller trash in the water, near the station, where it would be more convenient for cleaning, and a coarse rack over the end of the suction pipe in the river to intercept the larger débris.

In addition to such things as logs, cordword and branches of trees, this river water carried a large amount of semi-fibrous material, such as grass and small thread-like roots, for which a rather fine screen was required, and the screen must be arranged so as to be readily cleaned of the accumulation without interrupting the water supply.

This was accomplished by duplicating a short section of the suction pipe, just before it entered the building, with a cylindrical screen chamber in each branch and a gate valve each side of the screen chamber, the two branches being connected to the single pipe at each end, as shown in Fig. 1. Fig. 2 is a section through one screen chamber and an elevation of the other. The covers of the screen chambers were fastened by hinged bolts, which could swing through slots in the flanges, and with monkey-tailed nuts so as to avoid the use of wrenches.

The waste-water pipe from the condensers was laid in the same trench, but above the suction pipe, as shown in Fig. 2, and a 2-inch pipe led from the bottom of the waste pipe to each screen chamber, for filling the screen chambers after the screens had been cleaned and replaced.

In regular operation both valves were open in one branch and closed in the other. When the screen in use needed cleaning, which was about every six hours, the two valves on that side were closed and those on the other branch opened, thus diverting the water through a clean screen. The cover of the dirty screen was then removed, the screen frame, which set in grooves in the side of the chamber, was hoisted out, cleaned and replaced, the cover bolted on, the chamber filled with water through the 2-inch pipe from the waste pipe, an air cock in the cover allowing the air to escape.

This device worked so nicely that it

FIG. 1. PIPING CONNECTION TO STRAINERS

was impossible to tell by observation of the pumps when the change of screens was being made. The vacuum gage would show it, as the clogged screen would cause an increase in the vacuum necessary to raise the water, which increase was not allowed to exceed 2 or 3 inches, and as soon as the water entered the clean screen the vacuum would drop to its normal condition.

At the river end of the suction pipe, about 800 feet from the building, conditions were not so favorable. The river bank had been riprapped with heavy stone to prevent the bank being washed away, the slope being about 45 degrees and giving a good foundation to work on. Enough of the riprap was removed to make a trench that would cover the pipe, which was easily got into the water by making up a length of pipe on the bank, with a 45-degree elbow looking out stream on the lower end, and letting it slide endwise down the bank with a tackle to prevent it getting away. It was anchored firmly by filling the trench around the pipe with concrete, the irregularities of the riprap making a most excellent anchorage. On the upper end of the pipe another 45-degree elbow brought it in line for the pipe to the building.

A number of old 30-foot railroad rails were procured and laid on a temporary falsework over the inclined pipe, projecting out over the water, with the flanges up, and about 2 inches apart in the position shown by the dotted lines in Fig. 3. The reason for placing the flanges up was to insure that the openings between the rails would be wider on the inside, so that anything that would enter the openings would pass on through and not be wedged fast.

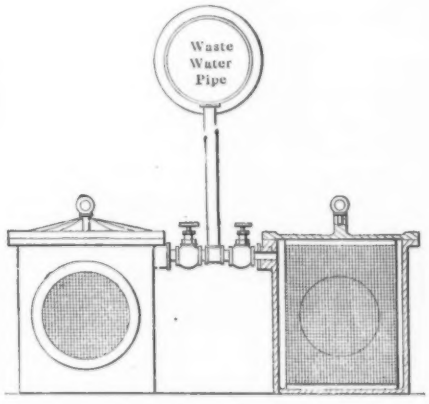


FIG. 2. STRAINERS IN ELEVATION

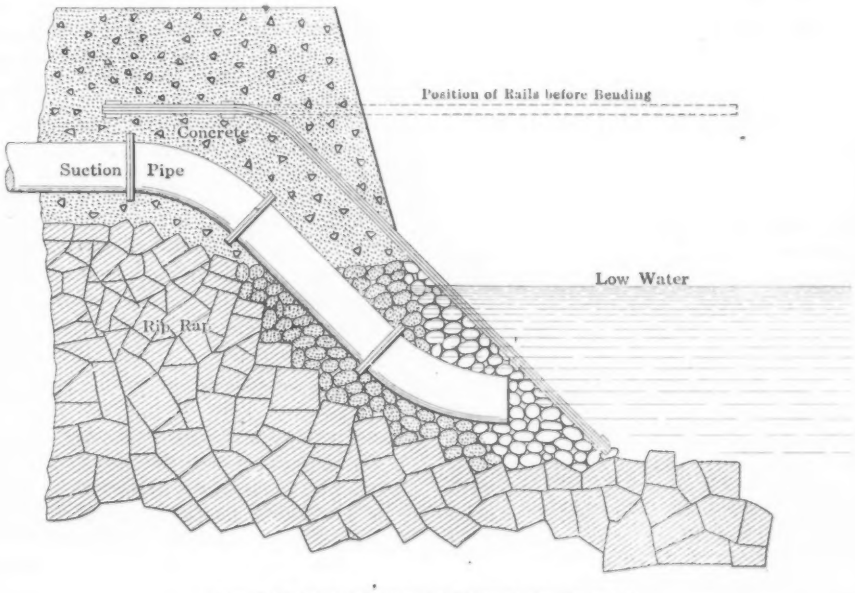


FIG. 3. ROUGH SCREEN AT MOUTH OF SUCTION

Two pairs of heavy, flat iron bars were bolted across the bed of rails about 5 feet apart at the shore end and one pair at the extreme outer end, with bolts between the rails to preserve the alinement. A substantial block of concrete was then

built around about 5 feet of the shore end of the rails. When the concrete had hardened, a pair of shear legs was set straddling the nest of rails, with a tackle hitched to the outer end by a sling long enough so that the lower block of the tackle would be above water. Having taken the weight of the rails on the tackle, the falsework was removed and a wood fire built around the rails just where they projected from the concrete, first placing a layer of sand between the fire and the concrete to prevent injury.

As soon as the rails were red hot, the tackle was lowered and the rails bent to a neat curve, making as neat looking and as serviceable a rack as anyone could wish for.

The waste-water pipe was diverted from its position over the suction pipe before the rack was reached, and delivered the waste water downstream from the suction inlet, the velocity of the river giving ample assurance that there was no danger of the suction getting any of the warm waste water.

Burlap bags filled with concrete were then worked under the submerged portion of the suction pipe, and the triangular openings each side of the rails were closed up in the same way. The bags of concrete projected a little above the water line, and wooden forms were set up and filled with concrete to make a neatly finished job. Fig. 3 is a section of the rough screen in the river.

Catechism of Electricity

927. *Why is the word "abnormal" used in connection with the heating of direct-current motors?*

Because all motors in operation develop a certain amount of heat which cannot be prevented and which is not therefore considered a defect.

928. *Explain why a motor in perfect running order develops heat while in operation.*

Considering the motor electrically, heat is developed at the commutator and brushes and in the field and armature coils because it is impossible to force a current of electricity through a conductor without heating it.

Considering the motor mechanically, heat is developed in the bearings, commutator and brushes by reason of friction between moving parts.

Considering the motor magnetically, heat is developed in the iron portions, such as the frame and magnet cores, on account of the passage of magnetic lines of force through them.

929. *Is it an easy or difficult matter to locate the cause of abnormal heating in a direct-current motor?*

It is often difficult because both the defective and perfect parts become of practically the same temperature owing to the ease with which heat is conducted through and between them.

930. *How should such a case be treated?*

Stop the motor until it becomes perfectly cool. Then start it up and operate it under full load for about five minutes. Stop it again and carefully but quickly test each part for abnormal temperature by the sense of feeling.

931. *Give some rules to guide one in testing for temperatures by means of the hand.*

The ability to determine accurately in this manner the amount of heat developed can be acquired only by experience. If the hand can comfortably be held on the iron portion of a machine for several seconds, its temperature may be considered as being within the safe limits.

In connection with this test the condition of the hand must be taken into consideration as well as the conductivity for heat of the surface touched. Inasmuch as the back of the hand is far more sensitive than the palm, more reliable results will be obtained by testing with the back of the hand. If the surface of the iron is rough there will be more radiation than if it is smooth and, in consequence, its internal temperature may be higher than the sense of touch would lead one to suppose. Then, too, any paint on the surface of the iron also affects to a considerable extent the conductivity of the internal heat.

932. *How can more accurate results be secured than by the sense of feeling?*

By using thermometers.

933. *Give some rules for testing motor temperatures by means of thermometers.*

The bulb of the thermometer should be placed against the surface of the part whose temperature is desired and it should be protected from outside influences by a covering of cotton waste, the whole being held in position either by hand or tied by means of a string.

In connection with this test it is well to note the temperature of the surrounding air at the time the other reading or readings are taken, for the atmospheric temperature has, of course, a direct bearing upon the temperatures of the various parts of the machine.

934. *What temperatures of the different parts of a direct-current motor would be considered abnormal?*

For the field or armature, over 50 degrees Centigrade above the surrounding air temperature; for the commutator or brushes, over 55 degrees Centigrade above the surrounding air temperature; for bearings or other parts of the machine, over 40 degrees Centigrade above the surrounding air temperature.

935. *Is there any other method of obtaining temperatures of the parts of a motor?*

Yes, there is an electrical method particularly well adapted for securing the temperatures of the field and armature coils. The inaccessibility of these parts renders the hand and thermometer methods rather inadequate for the purpose. The electrical method is often used as a check on the temperatures obtained on the field and armature coils by means of thermometers.

936. *Explain how to obtain the temperatures of the field and armature coils by the electrical method.*

After the motor has been run under full-load conditions sufficiently long to insure the maximum temperatures being reached, the machine is shut down and a moderate direct-current voltage applied first between any two opposite commutator bars and then between the terminals of the field coils. In each case the amperes of current are carefully noted on an ammeter, and at the same time the drop or pressures between the points of application are also read on a voltmeter. Having, then, the current through the armature coils and through the field coils, and the respective pressures across them, their respective resistances hot may readily be calculated by dividing the latter values by the former ones.

In performing this test care must be observed that the testing voltage does not exceed the normal voltage for which the armature winding or the field winding is designed, in order that the testing current does not injure or unduly increase the temperatures of these parts; it is also necessary to note by aid of a thermometer the temperature of the surrounding air in degrees Centigrade at the time these measurements are being taken.

Having, then, at an atmospheric temperature of $T°$, the resistance in ohms which we will designate $R_{T°}$, the next step is to calculate what this resistance would be at zero degree Centigrade. Designating this unknown quantity by $R_{0°}$, the formula used is

$$R_{0°} = \frac{R_{T°}}{1 + 0.004\,T°}.$$

By substituting for the terms on the right-hand side of this equation their proper values, and dividing the numerator by the denominator, the value of $R_{0°}$ will be obtained. This value, together with that of $R_{T°}$, when substituted in the equation

$$T = \frac{R_T - R_{0°}}{R_{0°} \times 0.004}$$

will give the temperature in degrees Centigrade, at the time the measurements were taken, of the armature coils or of the field coils, depending upon whether $R_{T°}$ is the resistance hot of the one or the other.

Development of the Surface Condenser

Combination Condenser and Feed-water Heater; Condensers for Use with Steam Turbines; Countercurrent, Contraflo and Other Types

BY WARREN O. ROGERS.

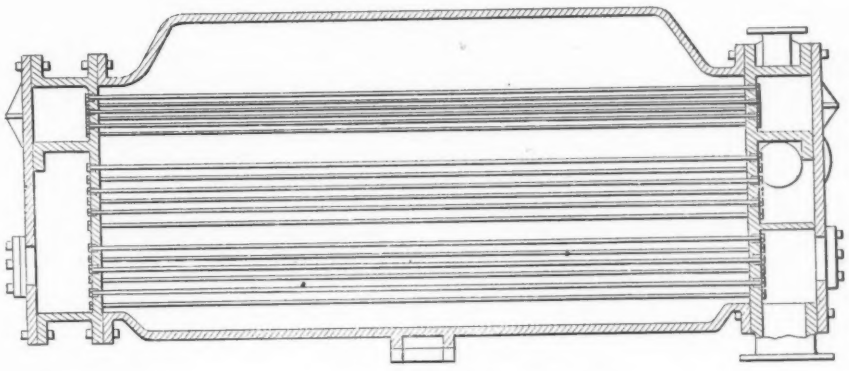


FIG. 15

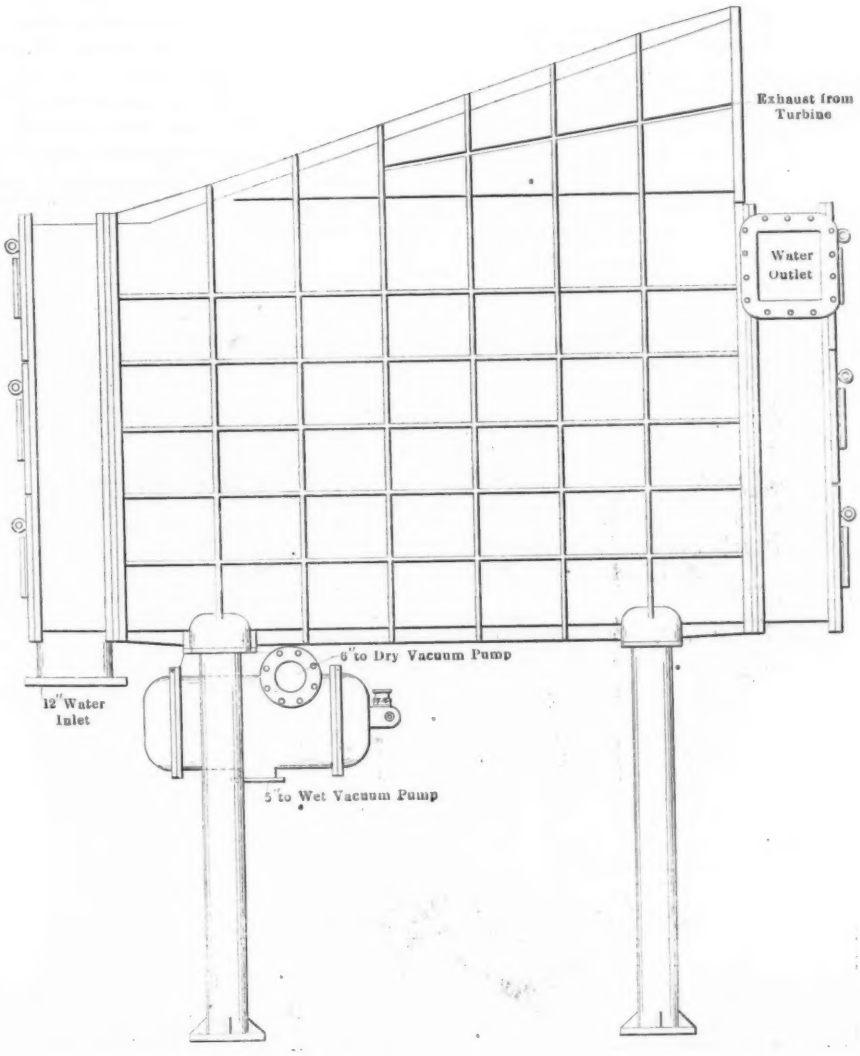


FIG. 16

As a condenser does not deliver the water of condensation to the hotwell at as high a temperature as the interior of the condenser, it must either be reheated in a heater or delivered to the boiler at a much lower temperature than is consistent with economy. A form of combined heater and surface condenser is obtained in the Volz surface condenser and feed-water heater, manufactured by the Wheeler Condensing and Engineering Company, and illustrated in Fig. 15.

This combination condenser and feed-water heater saves considerable floor space and requires but little more head room than the ordinary type of condenser for a given size. The upper part of the shell contains a set of tubes through which the feed water passes to the boilers. The lower part of the shell contains the condensing tubes. The heater and condensing tubes are connected to their respective chambers, which are separated by a partition wall of iron, by the method adopted by the makers in their regular type of condenser. As the heater tubes are in the direct path of the incoming exhaust steam, they are exposed to the hottest vapor.

A type of condenser used in connection with the steam turbine is shown in Fig. 16, and is manufactured by the Fred M. Prescott Steam Pump Company. It is made with a rectangular shell and an exhaust inlet which is especially designed to meet the requirements of the steam turbine. Fig. 17 shows a sectional view of the condenser, which contains the same features as the general run of this type of condenser. The tubes have supporting plates to prevent vibration. The air and noncondensed vapor are removed by a Prescott positive rotative dry-vacuum pump, while the condensed water is removed by either a rotary or steam-driven pump.

In Fig. 18 is shown a type of condenser not often mentioned in connection with the condensation of steam. It is designed to be placed either on the roof of the building or on a tower where the air can circulate through the tubes. Water is also used as a condensing medium flowing, as it does, over the tubes in a thin stream which, being caught in a tray at the bottom, is used over and over again, with only a small amount of fresh water added to replace the waste due to evaporation and other losses. The exhaust steam from the engine enters a header which is connected to several coils of con-

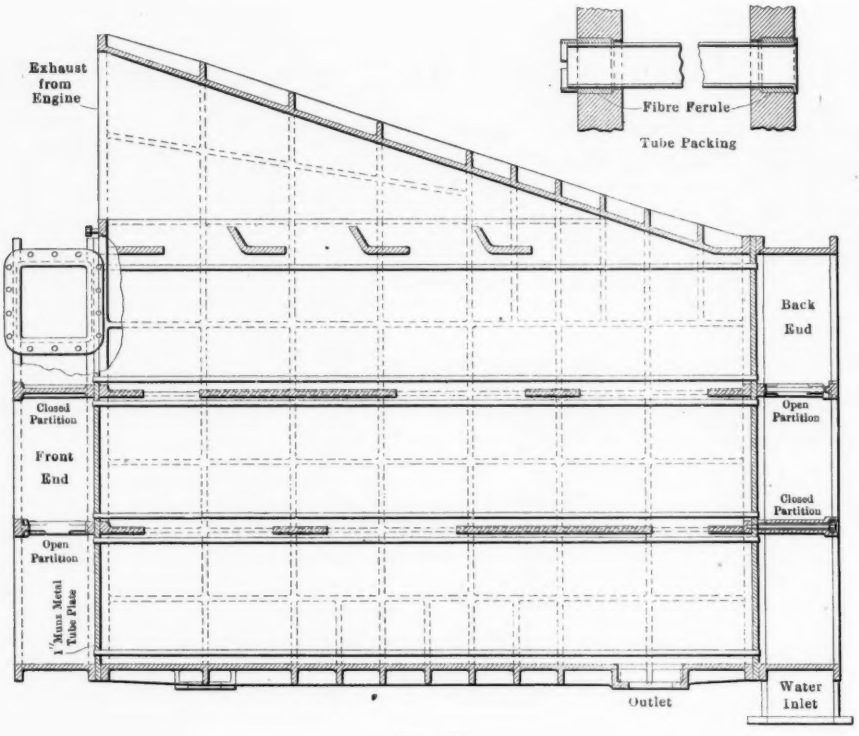


FIG. 17

densing tubes and is circulated through them from the top to the bottom. The top row of tubes in each set of coils contains steam; the next, partly condensed steam, the amount of steam decreasing, and the amount of water increasing as the lower lines of tubes are reached. The water of condensation and air are drawn from the tubes by an air pump located in the pump room, the suction being attached to a return header to which the lower tube of each coil is connected. The circulating water is delivered to a header located over the center of the condenser, with branch distributing pipes for each condensing coil. This type of condenser is manufactured by the Minneapolis Steel and Machinery Company.

In Fig. 19 is shown a countercurrent type of condenser, in which the vapor flows between the tubes, the steam line being parallel with the flow of the condensing water. The baffle plates cause the entering steam to flow in a direction parallel with the upper condensing tubes; when striking the end of the condenser body, the direction of flow is reversed; this operation being repeated as often as there are baffle plates.

Another type of countercurrent surface condenser is illustrated in Fig. 20. In this condenser, which is manufactured by the Alberger Condenser Company, the exhaust steam enters the shell of the condenser at the bottom, while the circulating water enters a water pipe at the top at one end and, after passing back and forth several times through the nest of tubes, becomes heated by the steam and leaves the condenser at the other end, at the bottom. As the exhaust steam enters the body of the chamber it rises and meets the tubes containing the hottest water first, and becomes partially condensed. It then passes up through, and around, the remaining tubes, which are cooler, and the steam is completely condensed. The air and the vapor which has not condensed collect at the top of the condenser shell, where they are dried and cooled by the cold water flowing through the upper nest of tubes before being removed by the air pump.

The water of condensation falls to the bottom of the shell and toward the entering steam. If its temperature is lower than the entering steam it acquires heat from it and, as a consequence, the water of condensation leaves the bottom of the condenser at a temperature equal to that of the entering steam. It will be seen that the distinctive features of this condenser are that the water not only circulates in a complete countercurrent, but the condensed steam and the incoming exhaust steam flow counter to each other. Owing to this arrangement of counter water and steam flow it is possible to reduce the amount of tube surface and circulating water, because the water of condensation carries off heat that under ordinary condenser conditions would have to be transmitted through the tubes to the condensing water. The air is removed from the condenser body from a point farthest from the water of condensation.

In contraflo condensers the steam flows at right angles to the condensing tubes. The latest design of this type of condenser is shown in Fig. 21 and following illustrations. It is manufactured by the Contraflo Condenser Company, Limited, London, and is represented in the United States and Canada by the Elwold Company, North American building, Philadelphia, Penn. The advantages claimed for this type of condenser are minimum cooling surface and circulating water, a high vacuum and high thermal efficiency.

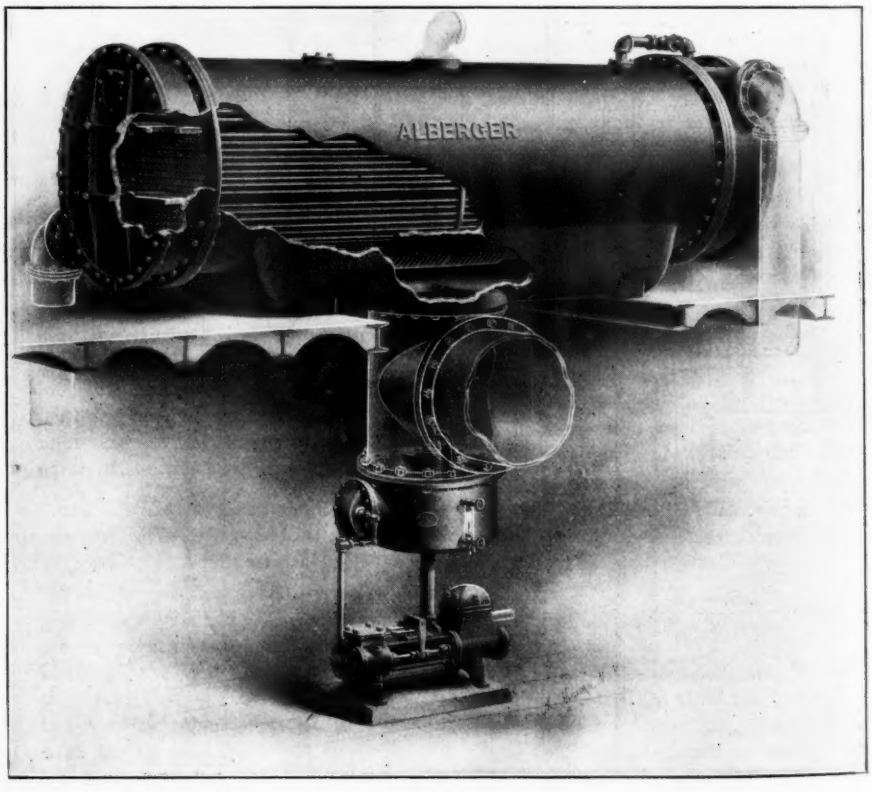


FIG. 20

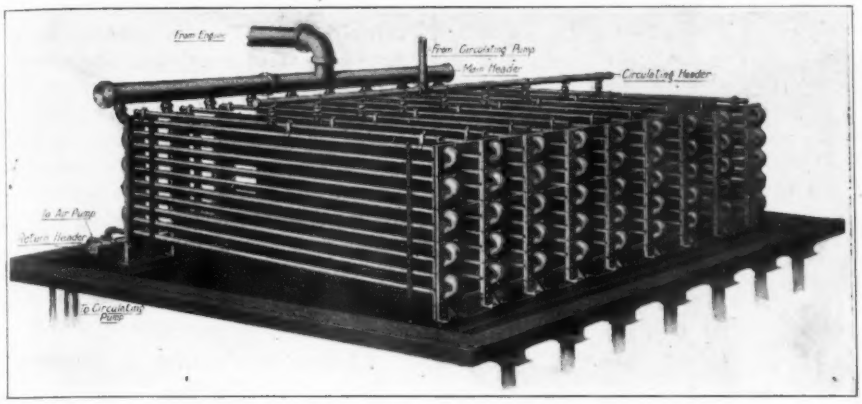


FIG. 18

In Fig. 22 is shown an end elevation of a contraflo condenser connected to a triple-expansion engine. The condensing tubes are arranged in compartments, as shown. The steam coming from the engine cylinder follows the path indicated by the arrows through the upper nest of tubes in an even flow over the entire length of each tube, and at right angles to them. As the steam reaches the upper tubeless chamber it reverses its direction of flow, because of the upper baffle plate, and passes over the second bank of tubes, reversing again in the next lower tubeless chamber and passing over the third and lowest nest of condensing tubes. As the tubeless chambers have ample area, the change in the direction of the flow of steam is not sudden. From the lowest nest of tubes the water of condensation passes to the air pump, changing its direction of flow for the last time in the tubeless space in the bottom of the condenser base. By this successive passing of the steam over all the tubes in one compartment, and again being uniformly distributed in the tubeless chambers already referred to, each tube is made to do a proportionate amount of work. The efficiency of the tubes is also increased because the steam in zigzaging down over the several nests of tubes increases its distance of travel, which increases the efficiency of the condensing surface.

The cooling water enters the lower nest of tubes as shown at *A*, Figs. 22 and 23, and, passing through the horizontal cooling tubes, reverses its direction of flow at the other end and returns through the nest *B*, reversing again and passing through the nest *C* to the other end of the condenser, where it is again reversed and returned through the nest *D*. The cooling water is then discharged through the

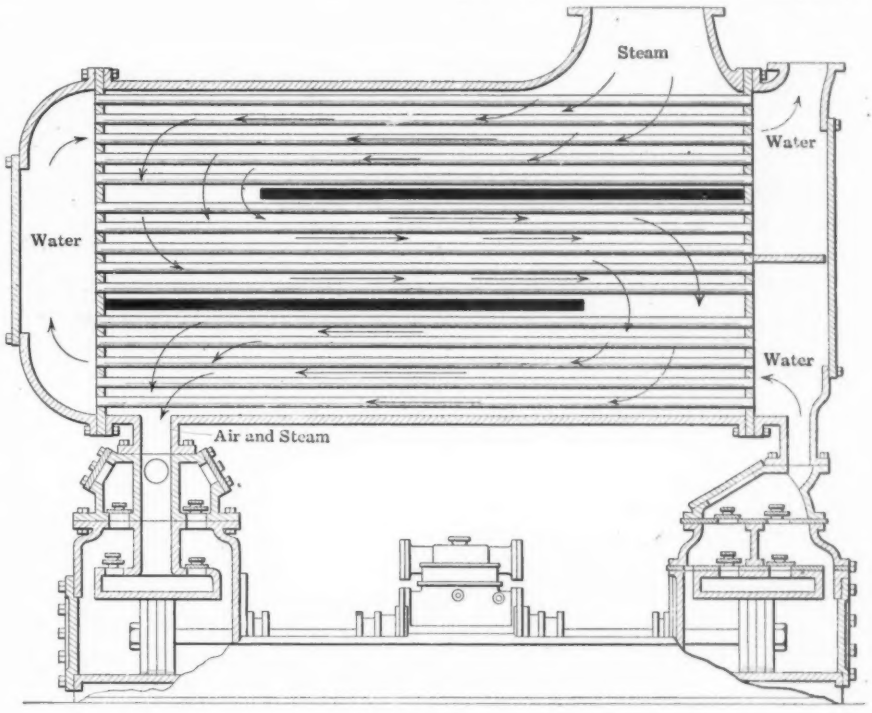


FIG. 19

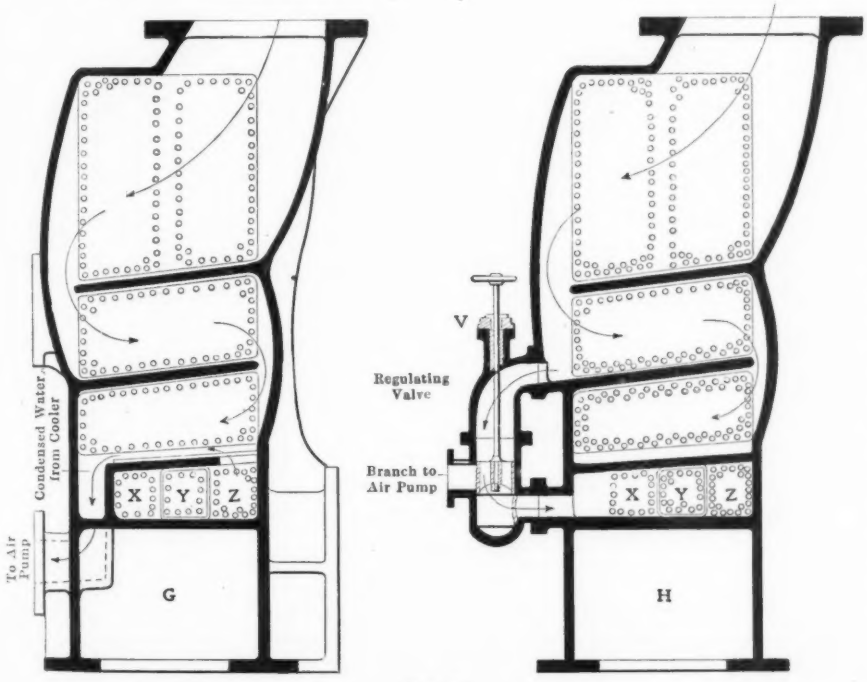


FIG. 24

outlet *E*, Fig. 23. From this it will be noted that the hottest water and steam are brought in contact with the cooling tubes at the top, while the coldest water and coolest steam and vapor are brought in contact with the cooling tubes at the bottom of the condenser body.

One of the reasons why the cooling tubes are very effective is because as the exhaust steam is condensed it falls to the baffle plate under the nest of tubes over which the steam is passing. As these baffle plates have lips turned down at the lower edge, overhanging the condenser tubes, the water of condensation passes by gravity direct to the bottom of the condenser body without coming in contact with the nest of tubes below. This same process of removing the water of condensation is carried out with each nest of cooling tubes, thus preventing them from becoming flooded by falling streams of water.

In order that the air pump may extract the greatest quantity of air from the condenser, it is necessary to remove the

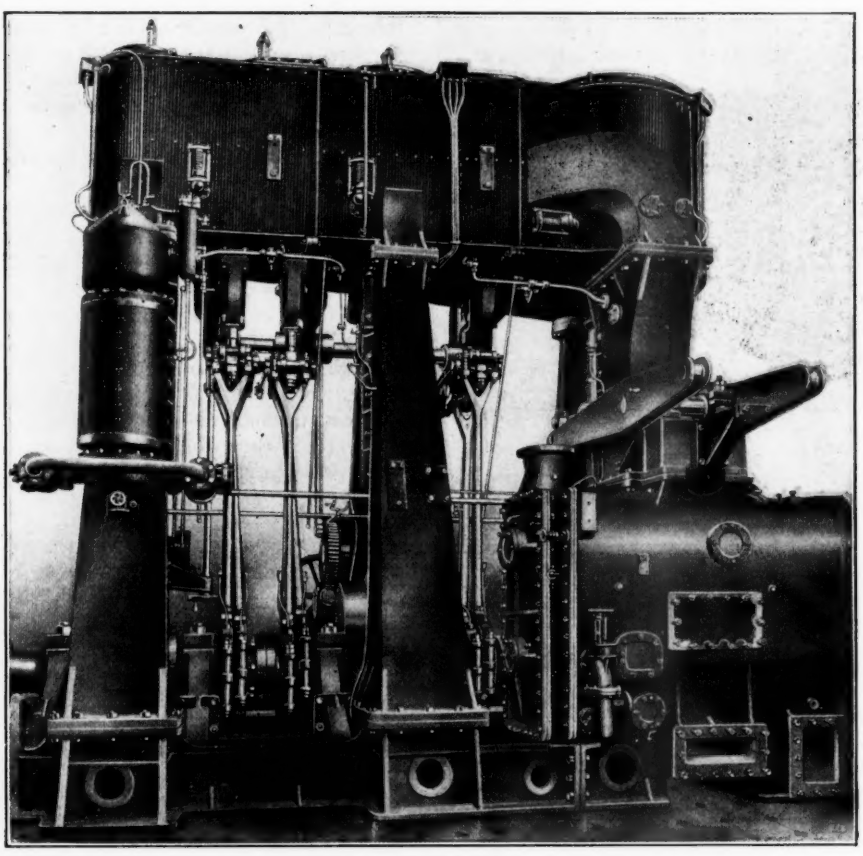


FIG. 21

vapor with which the air is mixed. In this instance a cooling chamber has been incorporated in the design of the condenser, which is placed in the bottom, as shown at *F*, Figs. 22 and 23. The sealing water, after passing through the air pump, is returned to the cooler, so that the same water is used over and over again. In case it is desired to obtain the highest vacuum, the entire feed water can be cooled down before passing into the air pump. On the other hand, when it is desired to maintain a fairly high thermal efficiency, the amount of water admitted to the cooler can be regulated so as to reduce the amount of water admitted to the cooler and lower the temperature of the air-pump discharge sufficiently to obtain just the vacuum desired. The cooler is, therefore, a ready means of increasing the effective capacity of the air pump. In Fig. 24 is shown a sectional view of the condenser and cooling chamber. In *G* is shown a sectional view of the condenser through *F*. In Fig. 23 is shown the outlet to the air pump for the condensed water after passing through the cooler. The sectional view *H*, Fig. 24, shows a section on *C D*, Fig. 23, and the arrangement for passing the condensed water direct to the air pump or through the cooler. This is made possible by the regulating valve *V*, Fig. 24. In *H*, the cooler is in three divisions; the condensing water first passes through the division *X*, entering the end on which is located the regulating valve; it then passes through division *Y*, and finally returns through *Z* to the outlet. By this arrangement of regulating the water of condensation and cooling water, the highest temperature of feed water under any given condition, and the ability to maintain the most economical vacuum at all seasons of the year, may be attained; at the same time, the power efficiency of the engine may also be raised to a maximum when desired, by raising the degree of vacuum considerably above the normal.

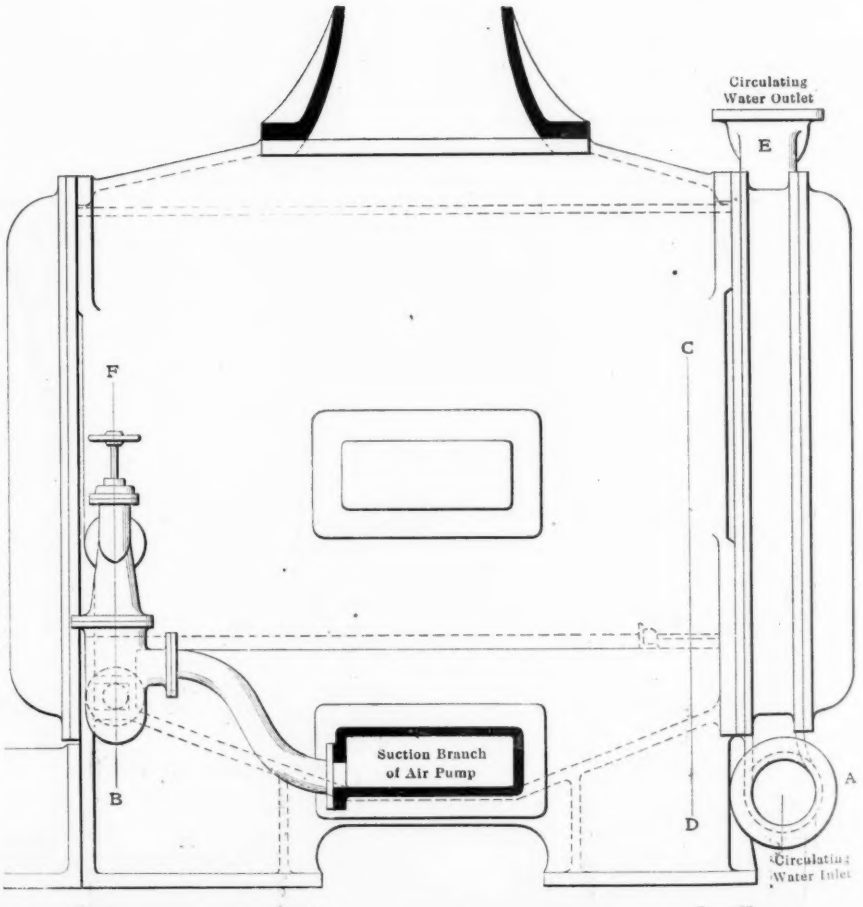


FIG. 23

Dinner of Alumni of Stevens Institute

The Alumni of the Stevens Institute of Technology will give their annual dinner on Friday, February 19, at the Hotel Astor, New York. A large attendance is expected, and among the speakers will be Alex. C. Humphreys, president of Stevens Institute; Alfred Noble, past president of the American Society of Civil Engineers and a former member of the Panama Canal Commission, whose topic will be the Panama Canal; Col. H. G. Prout, vice-president of the Union Switch and Signal Company; Dr. John A. Bensel, commissioner of the Board of Water Supply of New York City, and Col. George Harvey, editor of *Harper's Weekly*.

Monthly Meeting A. S. M. E.

The next monthly meeting of the American Society of Mechanical Engineers will be held on February 23, the fourth Tuesday of the month, instead of the second Tuesday, as usual. The subject of the evening's discussion will be "Safety Valves," introduced by a brief paper by Frederic M. Whyte, general mechanical engineer of the New York Central lines.

Mr. Whyte will discuss the principles of the application of safety valves to steam boilers with special reference to locomotive practice, including questions of design and construction, and the requirements and limitations of valves. His paper will be followed by a general discussion covering marine and stationary practice and conditions existing in connection with low-pressure heating boilers.

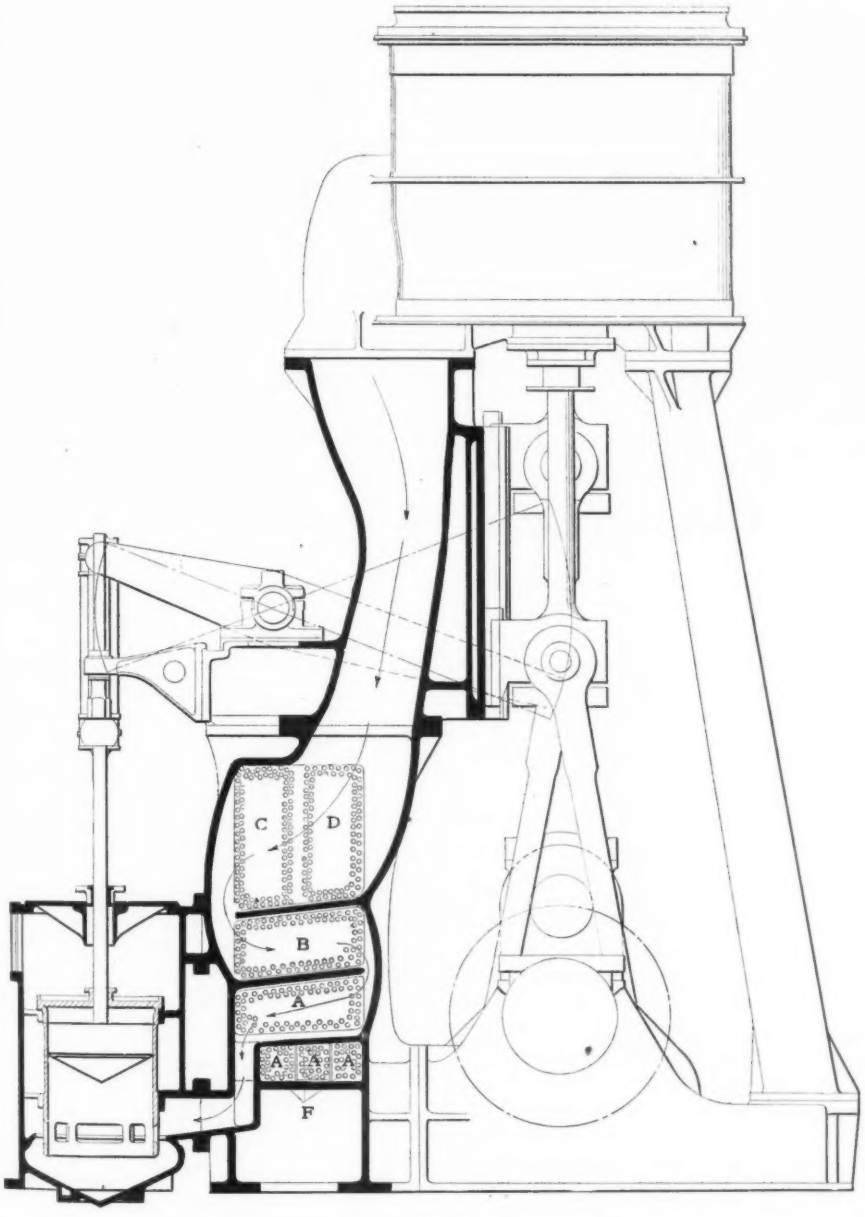


FIG. 22

Wisconsin Society of Engineers

It is proposed by forty or more engineers of the State of Wisconsin, representing cities, public utilities, manufacturing plants and colleges, to organize a State society along the same lines as those which are now in existence in Illinois, Indiana and other States.

The purposes of this society are to get the engineers of the State better acquainted with each other and to get a better understanding of problems that are of mutual interest to all, and to discuss some of the leading municipal and other problems of the day.

It is proposed to hold the first meeting in Madison, Wis., in the engineering building at the University on February 24, 25 and 26. Prof. F. E. Turneaure, dean of the College of Engineering, is chairman of the program committee, and W. G. Kirchoffer is secretary of this committee, to whom all correspondence should be addressed.

Phoenix Association Banquet

Phoenix Association No. 24, N. A. S. E., of New York, held its annual dinner on Wednesday evening, February 3, at the Broadway Central hotel. More than four hundred members and friends were seated at the tables. Although some were inconvenienced by the crowded condition of the large dining room, the committee succeeded in keeping everybody in good humor and a most enjoyable evening was the result. When the service reached the coffee and cigars, W. J. Fair, the toastmaster, introduced W. J. Reynolds, national vice-president; Joseph F. Carney and Herbert Stone, past national presidents; Thomas Cole, national conductor, James Westberg, S. I. Schaff and Arthur Vincent. The entertainers were "Joe" McKenna, "Billy" Murray, "Bob" Webb, Frank Corbett and "Jack" Armour. Frantzen's orchestra furnished the music. It is the social affairs of this kind that are drawing the engineers closer together for mutual benefit.

Personal

George A. Orrok, secretary of the Gas Power Section of the A. S. M. E., lectured on Wednesday evening, February 3, on the subject of the gas engine, before the Blue Room Engineering Society, at the society rooms at the United Engineering Societies building, 29 West Thirty-ninth street, New York.

George F. Swain, professor of civil engineering at the Massachusetts Institute of Technology, and H. E. Clifford, professor of electrical engineering at the Institute, have been elected professors at Harvard University in the School of Applied Science, established under the McKay bequest.

Samuel A. Spalding recently resigned as superintendent of motive power of the Brooklyn Rapid Transit Company to go with the Pennsylvania Railroad Company. His associates in the electrical-engineering department of the Brooklyn company gave a dinner in his honor, and later the power-house and substation employees presented him a diamond ring, at the same time honoring Mrs. Spalding by presenting her a cut-glass centerpiece for the table.

According to Consul-General S. Listoe, of Rotterdam, windmills are principally used in Holland for the purpose of pumping water out of drain ditches, which must be done regularly in order to keep the fields and meadows dry, the greater part of the Netherlands lying below the level of the sea. It is claimed that wind is too uncertain a motive power and gas motors are being introduced.

POWER AND THE ENGINEER

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February 9	37,000
February 16	37,000,

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"Available" Heat

In considering any engineering problem involving the transfer of heat one needs to keep constantly in mind the distinction between the heat units contained by a liquid or a vapor or a gas and the heat units in that liquid, vapor or gas that are available for the purpose under consideration. For example, exhaust steam at atmospheric pressure contains 1146 heat units, reckoning from the freezing point of water, but it does not necessarily follow that 1146 B.t.u. are available for heating purposes. If the substance being heated escapes at 148 degrees, then 1030 of the 1146 heat units can be utilized, theoretically. But if the substance being heated escapes at a temperature of 198 degrees, only 980 heat units can be extracted by it from each pound of the steam and condensate. (With "counterflow" heating the range would be increased.) With gases and liquids the case is even worse because there is no latent heat of evaporation as with steam. Gases at one thousand degrees thermometer temperature are 1460 degrees above absolute zero, and if they are applied to a substance which must be raised to 270 degrees (730 degrees absolute) then only one-half of the heat contained by the gases will be available, because when that one-half has been extracted, the temperature will have fallen to 730 degrees absolute and a condition of heat equilibrium between the gases and the receiving substance will be established. It is this phenomenon, coupled with the high latent heat in steam, which militates against utilizing exhaust gases from an engine for raising steam for power purposes, and it was the ignoring of these facts which led Mr. A. T. Kasley into error when he undertook to correct our figures on the quantity of steam that can be made with gas-engine exhaust heat. On page 61, in the January 5 number, he assumes that because the exhaust gases of an engine contain about 4000 B.t.u. per brake horsepower of engine output, this entire quantity is available for making steam, subject to the efficiency of the boiler. The facts in the case are that the absolute temperature of steam at 150 pounds gage pressure is 810 degrees, so that if the temperature of the gases were 1629 degrees absolute, only one-half of the heat, or 2000 B.t.u., would be available; and that if all of the heat could be extracted from the gases, as Mr. Kasley's computation makes it necessary to assume, then their pressure and temperature, and consequently their volume, would be reduced to absolute zero!

Without intending the least discourtesy toward our correspondent, we are moved by the incident to caution students and beginners in work involving heat phenomena to keep constantly in mind the significance of absolute temperature and the fact that heat, like water, cannot flow from a lower to a higher level (temperature). The proportion of the total heat that is "available" is determined by the difference between the temperature of the source and that of the receiving substance.

Replacing Old Equipment

It is the disposition of most steam engineers and managers to retain old equipment as long as it will do the work, regardless of its efficiency. It is a great mistake, however, to keep in operation a machine that can be replaced by one that will do more work at the same cost or equal work at a lower cost. That this assertion is true can be proved by a visit to any large, progressive steel mill, where in the "scrap yard" will be found thousands of dollars worth of machines with which nothing is the matter except that they are out of date—they have been discarded because there are newer types of machines that will do the work better, faster and cheaper. The same principle applies to the steam plant.

Much of the objection raised is due to the expense of replacing old units. It makes the man of money wince to see good hard cash put out for a machine to replace one that has been doing the work for years and is still able to do it. What the cost has been through lost time for repairs, low production in the factory due to unsteady speed, and waste of steam and fuel because of obsolete design, is not taken into serious consideration, mainly because the loss is not known, and "anyway it occurred a little at a time, so what is the odds?" The little losses do not hit so hard a blow, apparently, as the sum invested to prevent them; therefore they are allowed to continue. Some day the manager will wake up to the real significance of operating second-rate machinery, or a new manager will take matters in hand who knows that inefficient apparatus will not permit him to compete with the up-to-date establishment, and will bring about changes. The weeding-out process, although it costs money, pays.

Every steam plant contains drones that produce nothing. They should be removed and the space devoted to something that will produce results. In one instance an electric-light plant was operated day and night. The day load was small; so was the night load after midnight. The units consisted of one large engine belted to a line shaft from which were belt-driven three generators. Owing to the friction load of the shafting, belts, etc., it was necessary to fire two boilers during the light-load periods, although the use of a small engine and generator capable of handling the light load during the day and the greater part of the night would have allowed one boiler to be cut out, the wear and tear on the large engine and belting to be eliminated, and a considerable saving in steam and coal consumption

to be effected. Such a unit was finally installed and the saving has shown that its purchase was justifiable.

There are many steam plants in which may be found an old wornout engine carefully held for a reserve unit. Its days of continuous service have long since passed and the chances that it will ever be used again are most remote, but it will run if required, and its efficiency during the short and infrequent periods of its probable use is a matter of small moment. In this case the advantage of a standby or reserve unit is obtained at the expense of the interest upon what the old unit would be sold for practically as junk. In the same plant, perhaps, the feed-water pump "limps along on one leg."

Every engineer and manager can look about his steam plant and see where changes can be instituted that will be a means of increasing the economy of operation. "Improvements" can very easily be carried to excess, however, and a decision must be tempered with commonsense. An old slide-valve engine is just as adaptable for a sawmill as a Corliss engine, provided it will give steady speed, a factor which is usually lacking because of overloads. It is just as adaptable because in most cases the fuel not only is of no value, as it consists of sawdust, but must be got rid of, and burning it in the boiler furnace is the easiest way to dispose of it.

Homemade Appliances

From time to time correspondence describing various "homemade" devices is received, and we usually give it a place because engineers who might never appreciate the possibilities of such devices, or who might never be able to induce their employers to purchase them, may be induced to make them and be led into their use. As a general thing, however, appliances of such advantage as to be in general demand are to be had from the dealers in so much more efficient and presentable forms and at such reasonable prices that it hardly pays the user, especially if his time is worth anything, to build them on his own account. It stands to reason that a manufacturer, making things by special machinery and in quantities, devoting special study to their manufacture and profiting by the wide experience of the users of his wares, can turn out a more satisfactory article than the man who with pipe fittings and soft solder works out a single one. Nevertheless, the man who makes an automatically feeding oil cup, or a filter, or any of the many devices proposed, will find out some things about it which he might not otherwise have learned, and be in better condition to take care of the regular "store" article which he will doubtless eventually acquire.

The Surface Condenser

The steadily increasing use of the steam turbine has caused the condenser and its accessories to assume an importance entirely disproportionate to that accorded to it but a few years ago by builders and users of reciprocating engines. As has been many times pointed out, the turbine can use a high vacuum, and the reciprocating engine cannot. Theory shows that an increase of vacuum from 24 inches to 28 inches should increase the power developed from 1 pound of steam by some 18 per cent.; and with some types of turbine it is claimed that the actual gain is very nearly equal to that theoretically due. More commonly, however, the actual saving is slightly less than the theoretical, a rise of vacuum from 24 inches to 28 inches reducing the steam consumption by nearly 17 per cent. Though this saving is less than that theoretically due, it is, nevertheless, sufficiently substantial, and fully accounts for the importance attached to a high vacuum by all those engaged in the manufacture or supply of turbine-driven machinery. Any attempt to realize with a reciprocating engine any like proportion of the work due to a similar increase in vacuum would necessitate the employment of low-pressure cylinders rivaling in dimensions those, 14 feet in diameter, adopted by Captain Ericsson in his famous hot-air engine. In actual practice the saving effected by increasing the vacuum of a reciprocating engine from 24 inches to 28 inches is only about 2 per cent.; so that the lightheartedness with which the average marine engineer regards a bad vacuum is readily intelligible, and we have known even transatlantic liners worked regularly with a vacuum in the condensers of but 21 inches or so. Specifications even for tramp steamers often demand a 28-inch vacuum, and this may be obtained on trial; but in actual service anything above 25 inches to 26 inches may be reckoned exceptionally good in ordinary marine service. Higher vacua, though frequently recorded, are not often actually realized, and, when achieved, are very difficult to maintain, eternal vigilance being absolutely essential to success. Moreover, many records of such are undoubtedly due to the use of defective gages. As Mr. Morison pointed out at a discussion on this subject before the Institution of Marine Engineers, the ordinary Bourdon vacuum gage is most unreliable, forming a post superlative, in this regard, to the famous comparison, as to degrees of mendacity, in which the expert witness ranks third. We have known a vacuum of over 30 inches recorded on both gages of a cross-channel steamer fresh from her builder's hands, though the barometer stood at 30.5 degrees only, and the condensers were unassisted by a vacuum augmenter. Mr. Morison, at the meeting referred to above, described a visit to a power station in which three gages on the same service all recorded widely different vacua. On remarking to the engineer-in-charge that the gages seemed a bit erratic, the functionary named agreed, with the added remark that "it was only Wednesday at that." In explanation of this it may be stated that these gages were corrected every week-end; but had, nevertheless, agreed to differ to the extent mentioned by mid-week.

Great ignorance in regard to the principles governing condenser practice is to be found even in quarters where better might be expected. It is but three or four years since a prominent Rand engineer refused to adopt steam turbines because, owing to its hight above the sea, it is not possible in the Johannesburg district to obtain a vacuum of more than 26 inches, and better guarantees were obtained from reciprocating-engine builders than from turbine makers for plants to work with low vacua. As a matter of fact, the normal low barometer makes easier the maintenance of a low absolute pressure in the condenser, as part of the work of the air pump is already done by nature. The confusion doubtless originated in the English practice of reckoning vacua negatively—that is to say, an absolute pressure equal to 1 inch of mercury is reckoned as a vacuum of 29 inches. It is, of course, on a low absolute pressure that the economy of the steam turbine rests, and not on inches of vacuum recorded by an ordinary gage, which may mean almost anything, varying with each change in the atmospheric pressure.

The discussion at the Institute of Marine Engineers turned, to a large extent, on the claims for the "contraflo" condenser. In the "Gwladys," engined by Richardsons, Westgarth & Co., the tube surface in the contraflo condenser is only 1 square foot per indicated horsepower, in place of the usual 1½ square feet, yet, with sea water at 80 degrees Fahrenheit, there has been, it was stated, no difficulty in maintaining a vacuum of 27 inches, making use of a "cooler" arranged in the base of the condenser to lower the temperature of the air entering the air pump. It is rumored, moreover, that the exceptional results, in the matter of fuel economy, obtained by Messrs. Denny with the "Otaki," which is, it will be remembered, fitted with reciprocating engines, combined with a turbine, was at least partially due to the excellent vacuum, averaging about 28¾ inches, maintained by the contraflo condenser. Other builders claim that equally good results can be obtained with other forms of condenser; but, however this may be, engineers in general owe much to Messrs. Morison and Weighton for a clear exposition of the principles essential to really successful design.—*Engineering.*

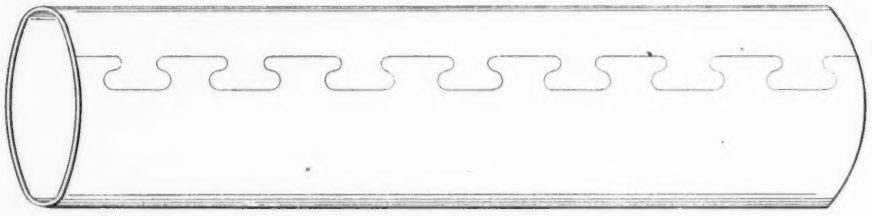
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Copper and Brass Pump Lining

The copper and brass lining shown herewith is manufactured by the Hamilton Copper and Brass Works, Hamilton, Ohio. These linings are used to line cylinders of large diameter, where seamless tubing above a certain diameter, say about 8 inches, becomes too expensive, when a lining made of composition sheet brass and sheet copper is substituted.



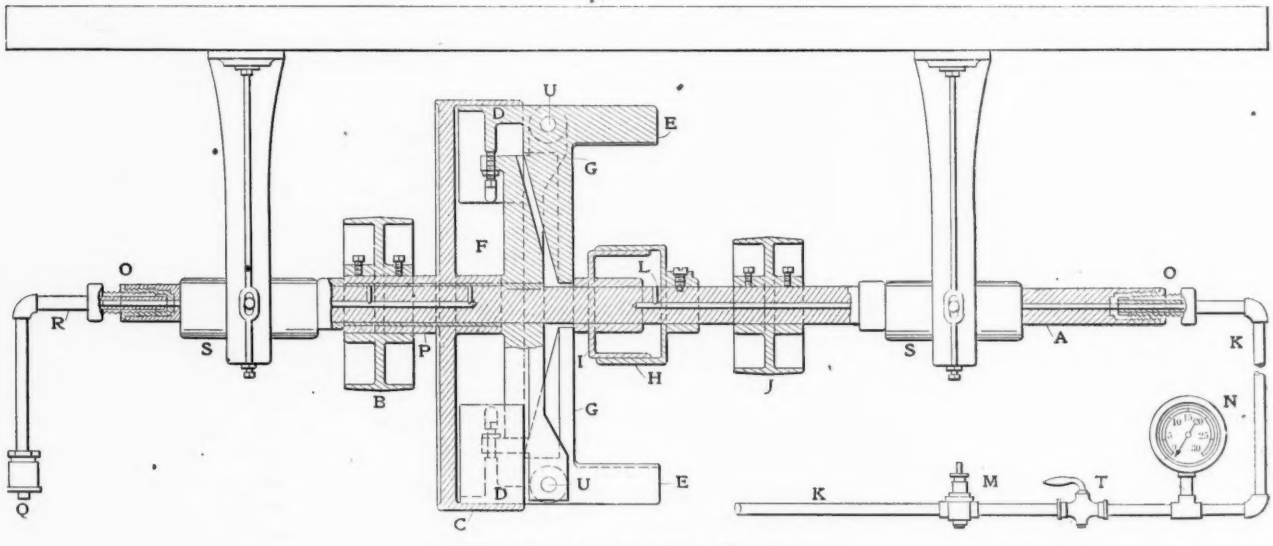
NEW PUMP LINING

The cylinders are bored out the size of the outside diameter of the lining and left in a somewhat rough cut. The linings are then pushed into the rough-bored cylinder. After this is done a burnisher or round-faced tool is placed in the boring bar and rubbed or burnished slowly, with a uniform pressure, against the lining from one end to the other. This brings the lining tight against the cylinder and also makes a smooth and polished surface. Plenty of oil is used when the lining is being rubbed against the cylinder. When this is done the ends of the lining, which should extend out about ¼ inch from the ends of the cylinder, are turned over the ends of the cylinder, making a water-tight fit.

A Variable Speed Clutch

The principles involved in this clutch and the method of speed control may be readily understood by reference to the diagram, where *A* represents a shaft supported by hangers *S S*, *B* a pulley driven by a belt from the line shaft, and rigidly mounted on the long hub *P* of the drum *C*. The pulley, hub and drum revolve together loosely on shaft *A*. At *D D* are clutch shoes, fulcrumed on the pivot bolts *U U* in the ends of the spider *F*. Integral with these shoes are the weights *E E* and the inwardly extending arms *G G*. The spider *F* is rigidly keyed to the shaft *A*. At *J* is a pulley fastened to the shaft. From this pulley, a belt passes to the machine to be driven. The cylinder *H* is secured to the shaft *A*, and rotates with it. One end of this cylinder is open and from this end projects the sliding piston *I* engaging the arms *G G*. An opening through the shaft communicates with the interior of the cylinder. When air or any fluid under pressure is admitted through the opening into the cylinder, the piston is forced against the clutch arms *G G*, thus forcing the weights *E E* inward and the clutch shoes *D D* outward toward and against the inner face of the drum *C*, causing the drum to impart its motion to the shoes. Acting against this tendency to impart motion, is the centrifugal force of the weights *E E*, which tends to separate the shoes from the drum and overcome the tendency of the drum to impart motion. It is the balance between these two forces that determines the speed transmitted.

In practice, the pressure on the piston, acting on the shoes and against the centrifugal force of the weights, imparts to the shoes a series of minute impulses that are apparently uniform, conveying steady rotary motion from the driving member to the driven member, the speed under no circumstances exceeding that which the regulating valve is set for. When pressure is released from the piston *I*, causing the clutch shoes to break contact with the drum, the drum acts as a loose pulley on the shaft. The controlling force is admitted to the cylinder from the supply pipe *K* through the stuffing box *O* and inlet *L*, regulation being effected by the



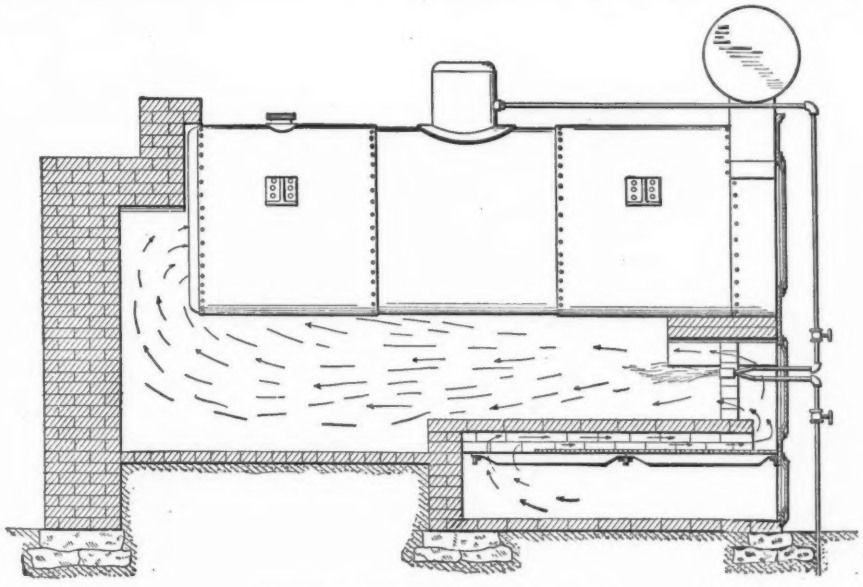
SECTIONAL VIEW OF VARIABLE SPEED CLUTCH

pressure-regulating valve *M*, the pressure being indicated by a gage *N*, the valve *M* being readily set to give any desired pressure. The cock *T* is used to turn on or off the supply of air, to start or stop rotation. At *Q* is a grease cup from which lubricant is fed through the pipe *R* and the central hole in the shaft and a small radial hole to the bearing surfaces of the sleeve *P*.

This clutch is manufactured by the Variable Speed Clutch Company, Milwaukee, Wis.

Mason Furnace

The accompanying illustration shows one style of preheated-air oil furnace constructed by the Mason Smokeless Combustion Company, 201 Kerchhoff building, Los Angeles, Cal. The method used in burning oil is the introduction of highly preheated air at the point of combustion.



MASON PREHEATED-AIR OIL FURNACE

As will be seen, the furnace is equipped with a brick arch over the grate, so constructed that the air in passing up through the grate is heated before entering the furnace proper, due to its contact with the brick arch.

It is claimed that by this method the air used at the burner is greatly expanded, heated by the heat produced in the combustion chamber, resulting in an instantaneous and complete gasifying of the oil.

The combustion is said to take place in the form of a short flame, the clear and transparent flux showing complete combustion of the gases and a very high intensity of heat which is rapidly imparted to the boiler body.

Greatly increased furnace temperature together with an even distribution of the heat is said to be the result, and all the available units of heat are therefore enabled to do their proper work of increasing the evaporation of water.

A New Line of Belt Driven Alternators

A new line of polyphase belt-driven alternators has been brought out by the General Electric Company for use in small generating plants and in isolated lighting and power plants where rapidly increasing inductive loads and consequently low-power factors are encountered. The machines are designed for 80 per cent. power-factor service, but will, of course, operate satisfactorily on higher power factors.

Fig. 1 is a general view of one of these generators. Although designed for belt drive, they are readily adapted for direct-connection to prime movers of suitable speed by omitting the driving pulley and subbase and adding a coupling. Each generator has on the collector-ring end of the shaft an extension to receive the exciter driving pulley.

The armature frame is of cast iron with cored ventilating openings which allow free circulation of air around the ends of the windings and through ducts in the laminated core, as illustrated in Fig. 2. The armature coils are form-wound and individually insulated, so that any coil may be readily replaced if necessary.

The field structure, which is the revolving member, consists of laminated magnet cores dovetailed into a laminated iron spider. The punchings are carefully stacked and riveted together, forming a rotor well adapted to withstand high speeds. Two methods of building the field-magnet coils are used. For the 50- and 75-kilowatt sizes the wire is wound on spools through which are slipped the magnet poles, the spools being held in place by the enlarged pole tips. In the larger sizes, the coils consist of a single strip of flat copper wound on edge so that one surface of every turn is exposed to the air. The collector rings are mounted on insulating sleeves on the shaft and are exposed to the air on all three sides. Two or more carbon brushes are provided for each ring.

As stated before, these generators have

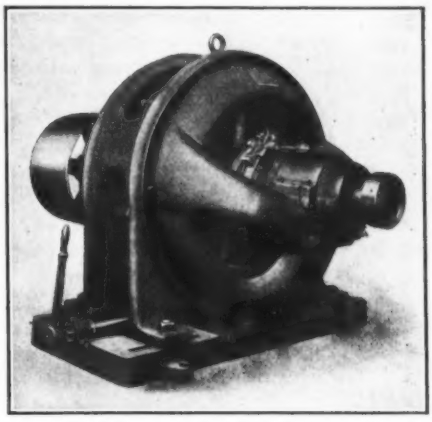


FIG. 1. A NEW BELT-DRIVEN ALTERNATOR

been especially designed for use in isolated plants where mixed lighting and motor loads are the rule rather than the exception. It is practically impossible in such cases to obtain good voltage regulation by hand control and some form of automatic voltage regulation must be

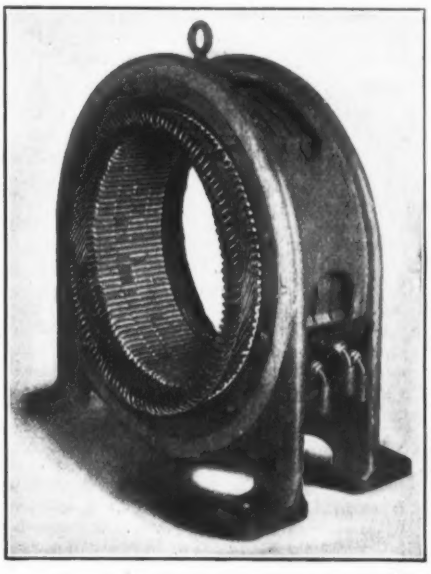


FIG. 2. STATIONARY ARMATURE OF BELTED ALTERNATOR

used. For this service the well known T A regulator manufactured by the General Electric Company is recommended and, when used in connection with the exciters for the P B alternators, automatically maintains practically constant voltage at the busbars or at the center of distribution, according to adjustment. The

exciters have a normal voltage of 125 volts, but are capable of delivering 150 volts continuously.. This margin of power enables them easily to overcome the demagnetizing effect of the armature current on circuits.

When intended for operation as synchronous motors, these generators are equipped with squirrel-cage windings set in the field-magnet pole faces. These windings are said to give ample starting torque with a moderate starting current and they do not in the least affect the operation of the machines as generators. The generators are at present available with either two- or three-phase windings and for 240, 480, 600, 1150 or 2300 volts.

Atlantic City A. O. S. E. Dinner

The twelfth annual dinner of Atlantic City Council No. 4, of the American Order of Steam Engineers, was held at the Hotel Jackson, Atlantic City, N. J., on Saturday evening, February 6. An excellent collation was served to over 150 members, friends and guests, among them being several prominent citizens of the city, and also many familiar faces of the engineering fraternity. Short addresses were made by Mayor F. B. Stoy, Harry Wooten, Fred Marcoe, supreme president of the A. O. S. E., and Commodore Louis Klunnel. An enjoyable entertainment was given by Charles E. Carpenter and "Jack" Armour. T. D. Just was the affable toastmaster. The committee in charge of the successful occasion were W. S. Price, A. H. Francks, J. W. Frampton, C. F. Noble, E. N. Meloney.

Business Items

J. Everton & Son, of Deer River, Minn., has placed an order with the Minneapolis Steel and Machinery Company for an 80-horsepower Muenzel producer gas engine and gas producer plant, and a 53-kilowatt double-cylinder generator, which will be direct-connected to the engine. This machinery will be installed in the electric light plant at Deer River.

The Southern Engineering and Supply Company has opened offices at 220 Avenue D, Henry Terrell building, San Antonio, Tex. They propose to make a specialty of pumping and irrigating machinery, also isolated and small light and refrigerating plants. Manufacturers interested in southwestern territory not having representatives are invited to send catalogs and descriptive literature.

The Burnite Machinery Company, with Thomas B. Burnite as manager, has succeeded the Burnite-Leonard Engineering Company, of Denver, Colo. The company has moved into a commodious office and storeroom at Seventeenth and Glenarm streets and represents the Hardsocg Wonder Drill Company, the Erie City Iron Works, the Bury Compressor Company, the Krogh Centrifugal Pump Company, and various other lines, making equipment for mine, mill or power plants of all descriptions.

The Fountain-Shaw Engineering Company, which began business the first of this year as civil, sanitary, electrical and mechanical engineers, with offices in the Binz building, Houston, Tex., is composed of Thomas L. Fountain and Joseph D. Shaw, with P. S. Tilson as collaborator. Until recently Mr. Fountain was assistant to Alexander Potter, civil and sanitary engineer, of New York City, and Mr. Shaw was assistant to the chief engineer of the Pittsburg Railways Company and the Allegheny Company.

The Crocker-Wheeler Company, of Ampere, N. J., has just closed a contract to equip with motor drive the new woodworking factory of the John Hofman Company, Rochester, N. Y. The order includes 40 induction motors ranging from 1 to 30 horsepower, with a total capacity of about 200 horsepower. These motors will be used for individual drive, each machine being equipped with its own motor. The motors, with the exception, of one, are of the squirrel-cage type. The generator for this plant and three lighting transformers are also included in the order placed with the Crocker-Wheeler Company.

The Buckeye Boiler Skimmer Company, South End, Toledo, O., has received a letter dated January 28, 1909, from Gilmore Brothers, contractors, Toledo, in which they say: "We have used your skimmer on our two dredges the past three years and find that they do all that you claim for them. We have worked alongside of other dredges, equipped with the same style of boiler, and whereas the others have had to clean their boilers every two weeks, we ran eight weeks before cleaning and then found no mud or scale. We open up our boilers every eight weeks, more to inspect them than in the expectation of finding mud or scale. We figure we save double the price of the skimmer each season, in fuel and time."

The Nelson Valve Company, Philadelphia, Penn., which was originally incorporated in the State of New Jersey, has surrendered its charter and has been incorporated in the State of Pennsylvania. This company began in 1893 to manufacture valves of all kinds under the Nelson patents and made such a success of the business that it now employs from 200 to 250 men. It is now proposed largely to increase the facilities so as to meet the growing demand for the company's product. The new charter will empower the company to manufacture and sell pipe, valves, machinery, fittings and steam specialties, and will have an authorized capital of one million dollars. The president of the new company, who was also president of the old one, is Samuel F. Houston, who is vice-president of the Real Estate Trust Company, and vice-president of the Winifrede Coal Company and of the Winifrede Railroad Company. Carlisle Mason is the vice-president and, as heretofore, general manager, and Russell Bonnell, the secretary-treasurer. Henry H. Bonnell is also one of the incorporators.

New Equipment

City of Elgin, Texas, has voted $30,000 bonds for construction of water works.

The Deer Lodge (Mont.) Electric Company contemplates installing engine, alternator, etc.

The Gilmer (Tex.) Ice, Light and Power Company has been incorporated with $40,000 capital by T. E. Barnwell, Lewis Monroe and J. E. Barwell.

The city council, Hartshorne, Okla., is said to have decided to construct water-works at a cost of $80,000.

The citizens of Ashburn, Ga., voted to issue $55,000 bonds for construction of electric-light plant, water works, etc.

It is reported the Le Roy (Ill.) Electric Light, Power and Heating Company contemplates the installation of a new heating and ice plant.

New Catalogs

Lehigh Stoker Company, Fullerton, Penn. Catalog. Mechanical stoker. Illustrated, 12 pages, 6x9½ inches.

Weber Steel-Concrete Chimney Company, Chicago, Ill. Catalog. Chimneys. Illustrated, 48 pages, 4x9 inches.

The Corbett Supply Company, Trenton, N. J. Catalog. General mill supplies. Illustrated, 520 pages, 6x9 inches.

Joseph Dixon Crucible Company, Jersey City, N. J. Pamphlet. Lubricating the Motor. Illustrated, 24 pages, 5½x8½ inches.

Dean Bros. Steam Pump Works, Indianapolis, Ind. Catalog No. 74. Condensing machinery. Illustrated, 56 pages, 6x7½ inches.

The Caskey Valve Company, 422 Arcade building, Philadelphia, Penn. Catalog. Valves. Illustrated, 19 pages, 3½x6½ inches.

The Jeffrey Manufacturing Company, Columbus, Ohio. Catalog 67D. Rubber-belt conveyers. Illustrated, 48 pages, 6x9 inches.

Eck Dynamo and Motor Company, Belleville, N. J. Sectional catalog and data book. Motors and dynamos. Illustrated, 5½x8½ inches.

C. O. Bartlett & Snow Company, Cleveland, Ohio. Catalog No. 28. Coal and ash handling machinery. Illustrated, 48 pages, 6x9 inches.

Jacobson Machine Manufacturing Company, Warren, Penn. Bulletin L. Gasolene power sprayers. Illustrated, 30 pages, 6x9 inches.

The Climax Smoke Preventer Company, Equitable building, Boston, Mass. Catalog. Climax smoke preventer. Illustrated, 16 pages, 6x9 inches.

Bush Terminal Company, 100 Broad street, New York. Catalog. Model loft buildings for shipper and manufacturer. Illustrated, 12 pages, 9½x12 inches.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

ENGINEER WANTED for small power plant in Pennsylvania. Must be sober, industrious. Address, with particulars, Box 1, POWER.

ASSOCIATE MEMBER of the A. S. M. E., aged 30, who has specialized on fuel economy and is carrying on a consulting practice with headquarters in New York City, desires to become associated with other consulting engineer or firm of consulting engineers, either electrical or mechanical, with offices in New York City. Box 100, POWER.

WANTED—By an engineering company in New York City, a wide-awake man with practical knowledge of plant operation in office buildings, to act as inspector. One with a general experience, but with full knowledge of elevators and meter testing preferred. A future for the right man. Address, stating age, experience and salary expected. Box 99, POWER.

WANTED—A good live agent in every shop or factory in the U. S. to sell one of the best known preparations for removing grease and grime from the hands without injury to the skin. Absolutely guaranteed. An agent can make from $5.00 to $25.00 over and above his regular salary. This is no fake. Write for free sample and agents' terms. The Klenzola Co., Erie, Pa.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

MACHINERY built to order; up-to-date plant. Write Brunswick Refrigerating Co., New Brunswick, N. J.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of

Recent Refinements in Boiler Testing

Descriptions of Apparatus and Methods Employed in Conducting Tests Along Uptodate Lines; Special Devices Used by the Author

BY ALBERT A. CARY

During many years of boiler-testing experience the writer has constantly endeavored to improve his testing equipment, so as to reduce the possibility of error to a minimum, to diminish the number of expert assistants required during a test and to make it possible *personally* to take all of the required observations with sufficient frequency to obtain ample data showing every important varying condition occurring during the test.

Probably one of the most troublesome matters connected with the equipment for boiler testing, where the engineer is called to conduct a special test, is the feed-water apparatus. I have used tanks, one of which is fitted upon a special scale platform and each charge of water is actually weighed before it is dumped into the lower tank which, acting as a sump, holds a reserve supply to be delivered directly to the feed pump. This arrangement requires the construction of a heavy platform of sufficient hight to allow the lower tank to be placed beneath it and it must be strong enough to carry both the scale and the upper weighing tank with (usually) two men who weigh the water and check each other's results.

If it is desired to keep track of the amount of water actually evaporated over each small interval of time during the test, the hight of the water in the lower (sump) tank, as well as the hight of the water in the gage glass, must be observed and noted at each reading of weight, and this very important information is thus secured with much difficulty and labor. Further objection to this system is due to the liability of the scale becoming injured or disarranged during shipment, and to the expense usually inflicted upon the owner of the plant for a properly built platform.

Water measuring is quite generally used in place of weighing apparatus, which admits of the use of a somewhat simpler equipment but with some sacrifice of accuracy. I have several designs for mounting such apparatus in place, one of which is sent to the steam-plant owner with instructions for erection. This equipment requires the lower sump tank and the upper measuring tank arrangement as before described, and whiskey barrels, which cost about $1.25 each, are usually employed. Two are generally used for measuring tanks, dumping into the same number of sump tanks, in testing boilers of less than 250 horsepower capacity. With such measuring barrels (the top

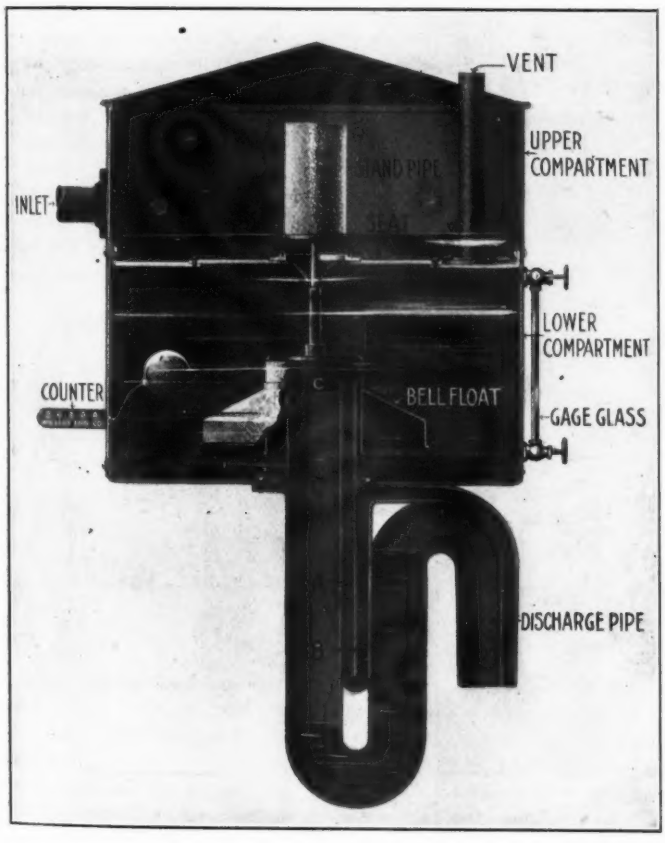


FIG. 1

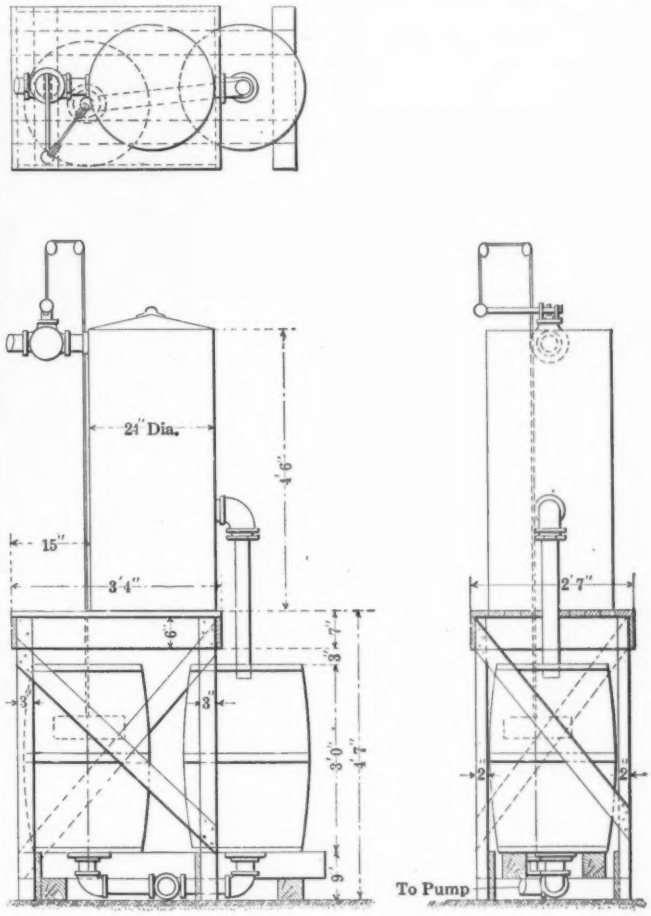


FIG. 2

heads having been removed) a hole is bored through each bottom head and a 2- or 2½-inch pipe flange is bolted to this bottom with a rubber gasket between the wood and the flange.

In the bottom flange of each of the upper (or measuring) tanks is screwed a nipple with a valve holding another lower nipple from which the water is discharged into the lower sump tanks placed below the level of the elevated platform. A hole is bored into the side of each of the upper, or measuring barrels, near the top of one of the staves, and into this is screwed a short length of pipe projecting into and outside of the barrel. Error is introduced in this form of apparatus in filling the barrel (from the lower closed valve to a level where the overflow pipe ceases to deliver water), due to the speed of manipulation sometimes found necessary, and to carelessness (often due to fatigue) on the part of those in charge.

Many special arrangements have been introduced by users of such apparatus to diminish this error. The opening and closing of the supply valves delivering water to these measuring tanks and the proper opening and closing of the discharge valves under these barrels involve considerable activity on the part of the man or men manipulating the apparatus, especially when it is worked anywhere near its capacity, to which work is generally added the clerical duty of keeping the water log, on which should be noted the exact time of each dump. Errors are sometimes introduced by opening the discharge valve before the overflow pipe has ceased to drip, by imperfectly closing the lower valves and occasionally owing to forgetfulness or to a rush when a sudden demand for more water occurs, due to failure in closing the discharge valve before the water-supply valve is opened to fill the barrel.

Where intention to deceive exists, this form of apparatus lends itself to easy manipulation despite the careful watching of the man conducting the test.

The lower barrels are connected by bottom piping so as to form practically one sump tank, from which lower connection water is piped to the feed pump.

In carefully conducted tests the common level of the water in the lower tanks should be noted in the log at the time of each dump from the measuring tanks, together with the level of the water in boiler-gage glass. With such information it is possible to determine whether a number of rapidly dumped barrels has been necessitated by a momentary large evaporation in the boiler, or by neglect in keeping the water in the boiler up to the level selected for the trial; or neglect in keeping the sump tanks full of water.

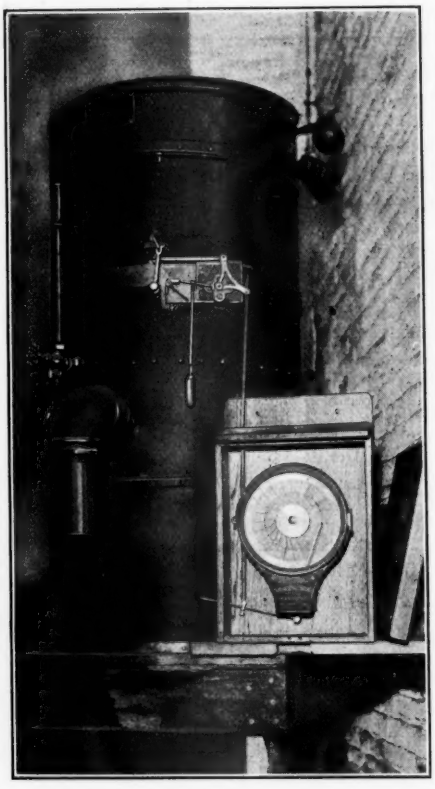


FIG. 3

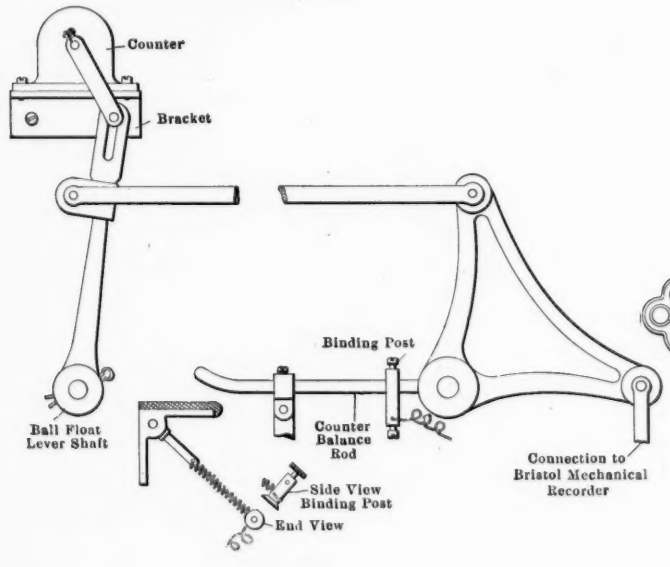


FIG. 4

Automatic Liquid Weigher

There have been many more or less automatic weighing or measuring tanks presented, to reduce the labor required in keeping account of the feed water used during a boiler trial, but nearly all of these have proved undesirable as portable apparatus, due to their considerable bulk or weight, or due to their delicate or complicated parts, to say nothing of their considerable cost in some cases; but finally, after investigating a number of these devices, the writer found what he has been looking for in a comparatively recent apparatus known as the Wilcox automatic liquid weigher. This weigher was described in a paper presented before the American Society of Mechanical Engineers at the May, 1906, meeting and it was also described in Power in the issue of June, 1906.

It is piped directly to the water system supplying the boiler, and after receiving a charge of water in its upper compartment, which charge is carefully weighed by balancing it against a column of water of a predetermined hight, the water supply is cut off within the tank automatically and the weighed charge is dumped; and then follows one weighed charge after the other, each successively dumped into the sump from which the water is delivered to the boiler-feed pump. A section of the apparatus is shown in Fig. 1.

If the supply of water to the weigher was not restricted, the continuous working of the apparatus would be apt to overflow the sump tank, but by placing a float in the sump tank and by connecting it to a balanced valve placed in the inlet piping to the tank (the tank being mounted upon an elevated platform) this valve automatically cuts off the supply of entering water

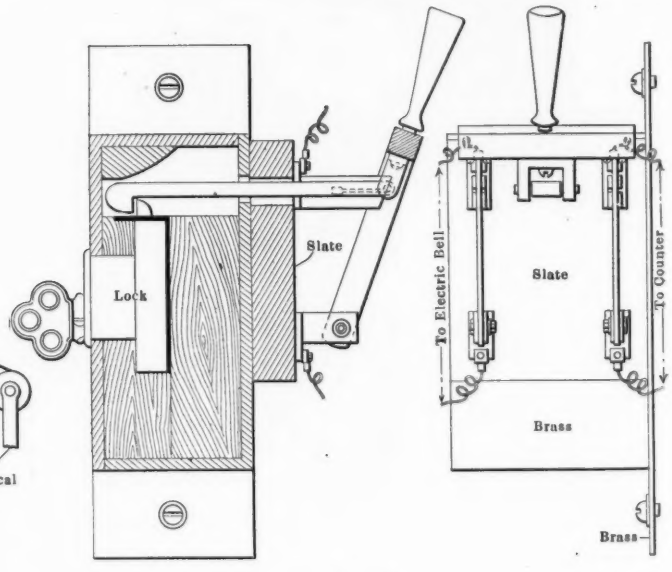


FIG. 5

when the level of the water in the sump tank rises above a predetermined level.

Each time this weighing apparatus fills and dumps, the rising and falling water level lifts and lowers a ball float within the lower compartment. This causes a small shaft, passing through the side of the apparatus, to make a partial revolution, first in one direction and then in the opposite direction, being actuated by the float to which the shaft is attached by a lever.

By referring to Figs. 3 and 4, it will be seen that the outer end of this shaft carries a lever, projecting upward, and having a slot at its upper extremity. This slot engages a pin placed at the bottom of the lever of a counter mechanism and as the top of the float lever moves backward and forward the counter is made to add one to the figure previously registered. Thus each dump is automatically registered on the counter.

The foregoing description presents the automatic weigher as it reached the writer, but after testing it carefully, and finding that it could be relied upon to deliver water with an error in weight of not over one-quarter of one per cent., and after subsequently using it in a boiler test it was found that the mere counter, showing the number of dumps, did not give sufficient information to follow the irregularities in evaporation occurring during the course of the boiler trial, unless very frequent readings were taken. The labor required in climbing up to the counter, located some 10 feet above the floor to obtain a reading every few minutes during the test (when numerous other readings had to be taken) was found to be quite fatiguing before the test was completed, so means were devised by the writer to overcome this objectionable feature.

To illustrate, roughly, what is meant by the necessity for frequent readings, let us suppose that the boiler evaporated 6000 pounds of water in one hour and 12,000 pounds of water during the second hour, and the counter reading was taken at the end of the second hour. It would be found that 18,000 pounds had been evaporated since the last reading. One would, by averaging, say that there was an evaporation of 9000 pounds per hour, which conclusion would give a very erroneous idea of what had actually occurred during this part of the test.

When carrying the regular steam load of one plant tested, I found this apparatus dumping its charges, during a short interval, every 40 seconds, while later in the test the dumps occurred about four minutes apart. In another test, where the heaviest demand for steam occurred in the afternoon, and where the owners could not understand why they could not maintain their steam pressure with two 80-horsepower boilers, I found that the average load for the day was only 147 boiler horsepower, but during one-half hour in the afternoon the steam requirements ran up to 257 boiler horsepower.

In order to obtain the full required data from this apparatus, I devised the attachments shown in Fig. 3 and shown with greater clearness in Fig. 4. To attach these to the sheet-metal weighing tank, a strip or band of brass, 2 inches wide, was firmly secured around the tank, running past the counter mechanism between the ball-float shaft and the bracket holding the counter. To this brass band a blocking was secured, carrying a lever with right-angled arms, similar to the so-called "bell-crank lever" used by bell hangers. It will be seen that the vertical arm of this crank is attached by a link to the vertical lever of the counter mechanism, which lever is oscillated by the rising and falling ball float in the tank. To the horizontal lever arm of this crank a second link is secured, dropping to the actuating lever of a Bristol time recorder, which instrument accurately revolves the recording-paper chart by clockwork.

By this arrangement, when the ball float in the tank rises with the inflowing water, the stylus of the recorder is moved away from the center of the chart (placed on the face of the recorder) toward its outer circumference. There it remains until the dump occurs, when the falling water level causes the stylus to move back toward the center of the chart.

These two approximately radial lines are traced on the paper chart with ink, when the stylus holds ink, but I have found a paper chart having its face coated with smoke much more satisfactory, as with very frequent dumps, causing these "radial" lines to occur quite close together, the closely adjoining fresh ink lines are apt to run into each other, thus causing an obliteration of the lines into a common blot. With the smoked charts (furnished by the Bristol company) lines lying quite closely together can be distinctly distinguished, and the very sensitively smoked face, with its contained record, is easily "fixed" after the test, so as to prevent the coating of soot from rubbing off.

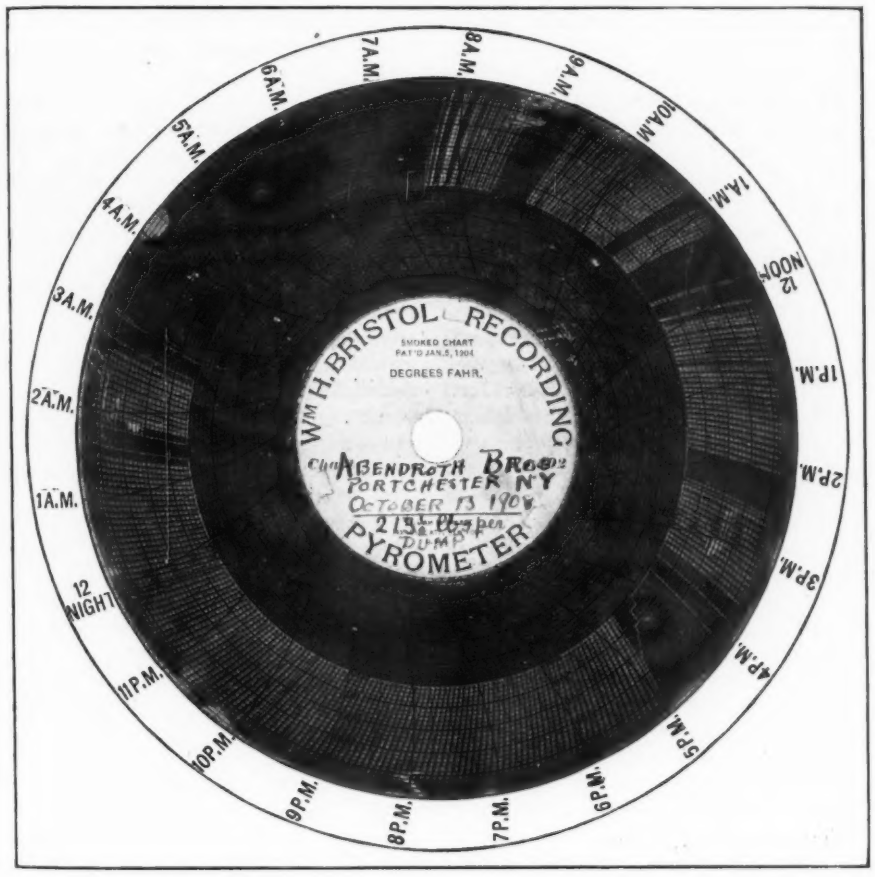


FIG. 6

Fig. 6 shows one of these charts with a record obtained during a test. The clock mechanism used in this case revolves the chart one complete revolution in twelve hours. The paper chart shown is made for use with a twenty-four-hour clock and, therefore, two of the hour divisions must be counted for one hour to interpret the record correctly. It will be understood that with double the number of time-division lines found on the twenty-four-hour chart the number of dumps in a short time interval are more easily determined.

An Electric Counter

Referring again to the mechanism shown in Figs. 3 and 4 a rod will be seen projecting horizontally from the hub of

the bell crank toward the float shaft. Weights are suspended from this rod to counterbalance the weight which has been imposed upon the lever operating the counter by adding the attachments to the clock mechanism. Having this convenient projecting rod, the writer was tempted to add another refinement to this weighing-tank mechanism which has proved a great convenience. I refer to an electric counter.

The inconvenience of using the regular mechanically actuated counter provided with the machine, and located some 10 feet above the floor, has already been referred to. To actuate the Mandi electric counter a circuit from a battery (of three dry cells) must be closed and then opened. The closed circuit from the battery must not be maintained long, otherwise the battery will soon be exhausted. In order to accomplish this result, I borrowed (by permission) part of the patented mechanism used in the Desper elevated-travel recorder. This is plainly shown in Fig. 4, where will be seen the outer end of the counterbalance rod projecting from the hub of the bell crank, placed directly over an angle-shaped brass wiper. This wiper is secured to the blocking holding the bell crank by an easy-fitting pin passing through the hub of the wiper near the apex of the angle.

To hold the wiper in the position shown with the least interference to its movement around its supporting pin, a short rod is secured in its hub, projecting at right angles to the pivotal pin and standing midway between the two arms of the angular wiper. To the outer end of this rod one end of a spring is attached, the other end being fastened to an electric binding post secured to the supporting blocking, and with this extension spring in tension the angular wiper must be held with its upper face horizontal but a very slight pressure applied near the end of this horizontal face will cause it to deflect and turn around the pivotal pin, and it will recover its normal position the instant this pressure is removed.

The upper or horizontal face of this wiper is covered with an insulating material which projects over its outer edge, but the under horizontal face presents a bare metal surface.

Electrical connections are made with the batteries and the Mandi electrical counter by connecting one wire to a binding post secured to the counterweight rod near the hub of the bell crank, while the other wire is connected to the binding post at the outer end of the wiper spring, the current being conducted through the spring and rod to the angle piece, as shown.

With this equipment, it will be seen that as the tank fills with water, the outer end of the counterbalance rod is made to descend and, striking the top insulated surface of the wiper, no current will pass through the system. As the water continues to fill the tank, the end of the counterbalance rod continues to descend and finally it slips over the edge of the insulated face, when the wiper springs back to its normal position, leaving the end of the counterbalance rod beneath the horizontal face, and out of contact with it.

The discharging operation of the automatic weigher requires a very short space of time, and as the water level falls the end of the counterbalance rod rises, striking the lower horizontal metal face of the angle and wiping over it as it rises thus closes the circuit and causes the electric current to flow through the magnets which operate the counter. As the end of the counterbalance rod continues its upward motion, it soon slips over the edge of the wiper, thus breaking the circuit, and this rod soon reassumes the position shown in Fig. 4.

With this device, it is possible to place the electric counter in any convenient position about the boiler room, where the readings can be taken with the least effort. With an autographic record, showing not only the number of dumps but also the exact time of each dump, the use of this electric counter may be questioned. I have found it most useful during the course of the test, showing as it does, almost immediately, the general evaporative result accomplished up to the time of the reading. With the many lines found on the recording chart, it is difficult to find time, during the test, to count them. By pasting a piece of paper on the front of the electric recorder just below the line of moving figures on its face, and by writing thereon the figure recorded immediately before the start of the test, it is a very simple matter to subtract this written figure from the recorded figure above, and then one has, almost at a glance, the number of dumps which have occurred during the test, up to the time of taking the reading.

Just below the initial figure on the pasted slip I write the exact number of pounds of water discharged at each dump, as determined by a previous calibration of the automatic weigher. With all of this information in plain view, anyone interested in the test may, by multiplying the number of dumps by the weight of each dump, which I do very rapidly on a slide rule, obtain the number of pounds of water fed to the boiler up to that time.

The average temperature of the feed water and the steam pressure are soon found, and we can then easily determine the number of pounds of water evaporated under these conditions; required to show a heat absorption of 33,305 B.t.u., which constitutes a boiler horsepower. This is found to be 30 pounds with feed water at 100 degrees Fahrenheit and with a steam pressure of 70 pounds, and 34.488 pounds with feed water at 212 degrees Fahrenheit and with steam at standard atmospheric pressure.

We have merely to multiply this "horsepower conversion figure" by the time elapsed since the test began (in hours) and divide this product into the pounds of water fed to the boiler, to obtain with close approximation the average boiler horsepower that has been developed. This is done quickly on the slide rule, and with equal rapidity, by the use of another apparatus described hereinafter, there can be known at any instant the average evaporation of water per pound of coal stoked to the boiler. Such information is not ordinarily obtainable until after the conclusion of the test, and then it is often too late to straighten out mistakes or irregularities that may have occurred.

Advantages Gained by the Use of This Apparatus

The advantages gained by use of an automatic water apparatus of this kind must be quite apparent. In the first place, the stand required to mount this weigher, as shown in Fig. 2, costs but about $5, and by using two whiskey barrels for a sump there is added but $2.50 to this amount. No extra observers are required to note the quantity of water delivered to the boiler and check each other's results.

With the float operating in one of the sump barrels, the one which does not receive the discharge from the weigher, and with this float connected by a small "jack chain" to the lever of the balanced valve which regulates the flow of supply water to the automatic weigher, the necessity of constantly noting the hight of the water level in the sump tanks is done away with, as I have found the level of the water in the sump constantly falling and rising between two fixed levels which do not vary ⅛ inch. We therefore have only to note the level of the water in the boiler's gage glass to make corrections for periodic water readings, and as long as the water level in the boiler is kept at a constant hight the necessity for all such water-level readings is done away with.

The regularity with which the water is supplied to the boiler may thus be noted by a mere glance at the lines shown on the chart of the autographic recorder. If the demand for steam from the tested boiler is constant, these lines should be very regular in their spacing; otherwise, the trouble may be traced to a careless water tender, who may allow the water to drop or rise to an inexcusable distance below or above the string tied around the water-gage glass. The best results in a boiler test are generally obtained by keeping the water at a constant level, rather than allowing this level to fall far below the selected hight and then periodically rapidly forcing in large quantities of cold water.

If the fluctuating load of a plant is carried by the boiler tested, and the water level in the boiler is kept constant, the recording chart will show the exact fluctuation of the load by the unequal spacing of its lines. This fact proved very useful in a plant I tested where an elec-

trical equipment was to be substituted for the steam-operated plant. The whole characteristics of the load were thus exhibited, showing the variations in load to be cared for by the electric generator.

In testing steam engines or turbines for their steam consumption, when they are operated under a varying load, the indicator card or brake load at any instant is easily compared with the chart of the automatic weigher by noting the amount of water evaporated at that same time. In competitive boiler or furnace trials, the regularity with which each boiler is operated is easily compared by reference to the autographic chart, and there are numerous other advantages to be gained by use of this water-recording apparatus, which I will not attempt to recite.

Coal Recording

Having thus developed the water-accounting apparatus, I turned my attention to coal recording, which is hardly capable of equal refinement without considerable complication.

Where a good iron wheelbarrow is found, as is the case in most boiler rooms, a runway from the floor is usually constructed upon which the wheelbarrow can be wheeled on and off a platform scale. The tare weight of the empty wheelbarrow is then noted and a 200- or 300-pound weight is added to this tare weight on the scale beam (according to the size of the wheelbarrow) and the wheelbarrow is filled with coal to balance this weight.

I usually have about half a shovel of coal in addition in each barrow load, which is thrown into a convenient dry iron ash can, to obtain an average sample of coal used during the test. This sample is carefully crushed and quartered down at the end of the test, and the last quarter is filled into a Mason fruit jar of two quarts capacity and hermetically sealed.

In order to keep track of the quantity of coal used over definite intervals of time during the test, I have the floor in front of the tested boiler carefully cleaned, so that there will be considerable distance preserved between the coal used for the test and any other coal in the boiler room. I then have dumped a single barrow load of coal at a time in this cleared space. If the smaller wheelbarrow is used it is known that each dump represents exactly 200 pounds of coal, and no more coal is delivered to the fireman until this last barrow load has been entirely stoked to the furnace.

In order to obtain a useful record of this coal, and have my attention positively called to each delivery of coal to the fireman, I invented a simple apparatus which is operated by the fireman; combining a two-pole electric switch with a Yale lock from which is operated an electric bell which can be heard throughout the boiler room, and an electric counter, the same as is used with the automatic water weigher.

When the last weighed charge of coal is completely stoked to the furnace, the fireman throws in the switch, which rings the bell and registers one more on the electric counter. To avoid the possibility of mistake by the fireman, or meddling by someone else, this switch is constructed so as to be securely locked (by the Yale lock) the instant the electric contact is made. Thus it is impossible to pull the knife of the switch out of the clip contact until I open the lock with my key.

The moment the bell rings I note the time on my log and, going to the scale, I see that the proper weight of coal is in the wheelbarrow. I also assure myself that the last of the previous charge of coal is in the furnace, and then I see the next charge of coal dumped. In the meantime I insert my key in the lock and thus release the switch which stops the ringing of the bell and throws the switch handle back in position to be operated again by the fireman.

The electric coal recorder thus adds up the number of fixed charges of coal stoked to the boiler and, by subtracting the number noted on the pasted paper slip on the face of the recorder, which is the number found on the counter immediately before the commencement of the test, from the last number automatically recorded, anyone interested may quickly see the number of wheelbarrow loads used since the test was started. By multiplying this result by the weight of each barrow load (also noted on the pasted slip) he may quickly determine the weight of coal used up to that time.

As I place both the electric coal and water recorders next to each other, at some convenient location, it is easy to determine approximately the number of pounds of water evaporated per pound of coal up to the time of the observation, and any change in the result thus obtained during the course of the test can be immediately accounted for. Events are thus noted which are apt to be lost sight of, or unaccounted for satisfactorily, in cases where the results of test are not known until after the test has been concluded.

Some discretion must, of course, be used in interpreting these results during the course of a test. Early in the test a considerable excess of coal consumption will generally be shown, due to building up the fires and heating the boiler walls and surroundings; while the reverse condition may be shown near the conclusion of the test when the fire bed is being burned down. Thickening or thinning the fire bed during the test, as well as the time of cleaning, must be taken into consideration, and also the amount of consumed fuel in the firebox; but one experienced in furnace work should have no difficulty in making such allowances, and the noting of such conditions will frequently prove of value when the results of a test are found to be in any way out of the ordinary.

The duration of a test should be continued until a sufficient number of even and regular results are obtained to show the normal characteristics of the furnace or boiler under trial, and the system described for recording results during the course of the test will enable the testing engineer-in-charge to know before he finishes whether he has secured this desired information. It is a very simple matter to obtain an autographic record of the coal consumption during the test by using a second mechanical recorder operated by an electric solenoid. The writer has worked out the details of such an apparatus and may adopt it in future test work.

Yale-locking Switch

As the details of the locking switch used may be of interest, the following description is given: By referring to Fig. 5 it will be seen that the Yale cylinder lock used is inclosed within a brass case. A regular two-pole electric knife switch is secured to one side of this brass case and between the two knives of the switch, and in line with the central handle, a fork bracket is secured. Between the two prongs of this bracket a brass tongue or latch is hinged by an easy-fitting pivot. This latch, projected within the lock case, has a hook-shaped end which engages the spring bolt or latch of the lock. When the key is turned, this bolt is drawn into the body of the lock and the switch latch is then free, so that when the handle of the switch is moved out its knives may be withdrawn from its clips or contact pieces.

In my latest design this operation of opening the switch is performed by the action of a torsion spring, the switch handle flying out automatically as soon as the key in the lock is turned. The switch, thus opened, is then ready for the fireman, who closes it when his last charge of coal is entirely stoked into the furnace. As one pair of poles of this switch are connected to the electric bell, and as its second pair of poles are connected to the electric counter, the closing operation operates both of these apparatus and the moment this double operation takes place the switch is locked so that it cannot be opened without the key. I locate this locking switch in a convenient position for the fireman, usually upon a vertical plank secured to the boiler front between two adjoining boilers.

Calorimeter Tests

With the coal and water records thus cared for, so as to secure the greatest accuracy with the least amount of labor, there will be found another series of observations in boiler testing which become tiresome and exhausting to the observer before the end of the test. I refer to taking readings of the thermometers used in

the throttling steam calorimeter. In most cases I place the perforated collecting nipple of the calorimeter in the vertical run of pipe leaving the steam outlet from the boiler. With the calorimeter placed at this position, an observation means a climb to the top of the boiler, a walk across the hot and dirty roof of the boiler setting, frequently with several steam pipes to climb over or dodge, and then the troublesome thermometer reading in an atmosphere of steam (which steam is necessarily emitted from the calorimeter), and this trouble is greatly aggravated if one wears glasses, which become clouded with vapor. To overcome this trouble, I use the telescope borrowed from my surveyor's level.

Frequently, the telescope can be placed in a convenient position on the boiler-room floor, and as it magnifies the thermometer scale and mercury the readings are taken with the greatest ease, a gas or electric light being placed in front of the thermometers to illuminate the scales. When the calorimeter is placed in a position where the thermometers cannot be seen from the boiler-room floor, I am sometimes able to place my telescope near the top of a ladder, on the outside wall of a battery of boilers, which merely necessitates a climb to the top of the ladder, without the hot objectionable trip over the top of the boilers, when a reading is to be taken.

I have also used another means for obtaining the readings from these inaccessible thermometers by placing concave mirrors (similar to those used as shaving mirrors) back of the calorimeter and after thus magnifying the thermometer scale I obtain a reflection of these images from the concave mirrors upon a plane mirror, placed in a position where it can be seen from the boiler-room floor. I then take my reading from below the plane mirror through the telescope.

To prevent these mirrors from clouding with the steam I rub their faces with pure castile soap, cleaning them afterward with a soft rag until they are bright. The same method can be employed in coating the lenses of eye glasses, to prevent their clouding in an atmosphere filled with escaping steam.

The foregoing means for making observations during a boiler trial reduce the amount of fatiguing work necessary in conducting such tests very materially, and with the least amount of energy expended the engineer-in-charge will find himself in better condition to follow all the details of the test very closely from start to finish.

There are other minor details used by me which also contribute to this end. For example, in reading the steam gage, draft gages, the nitrogen-filled thermometer for temperature of escaping gases, the feed-water thermometer, etc., I frequently use opera glasses to excellent advantage. Sometimes, for taking temperatures through the boiler setting, between the furnace and the chimney, I use thermo-electric couples, protected in quartz tubes which are connected to a multipole switch. By throwing the switch to its several pairs of poles, the readings are taken one after the other in rapid succession on a single millivoltmeter. I have under consideration, with Mr. Bristol, the construction of a pair of sensitive thermoelectric couples for use with the throttling steam calorimeter, which will be quite unique in principle of operation.

The testing engineer finds it very necessary to keep close track of the time during the course of the test and in order to do this with the least effort I use a leather wrist bracelet which holds a watch. When holding the board carrying the log sheets, the face of this watch is in plain view, and the exact time of the observation is thus easily read and entered on the log sheet.

With this equipment I have been able to take, *personally,* with comparative ease, every reading of instruments used during a commercial boiler test, with intervals between all readings of not over 15 minutes, and have a good check on the coal and water observations in the recording and autographic apparatus.

In such tests I have also been able to find time to make numerous gas analyses, by the use of a special gas-collecting and analyzing apparatus which allows me to obtain the percentage of CO_2, O, CO and N (by difference) contained in the furnace gases in five minutes' time.

The only assistance I have needed in these tests is a fireman and a man to load, wheel and dump the coal. Further, the use of these means has enabled me to remain the greater part of the time in front of the boiler, where I can personally observe all that occurs there during the time of the test.

The Tuileries hydroelectric works, the largest of the kind in France, now nearing completion, is 10 miles from Bergerac (Dordogne). It is designed to develop 23,000 horsepower. It is built on the Dordogne river, which has been dammed. The water drives nine 2700-horsepower turbines. The hydraulic works is supplemented by a steam works with Curtis turbines and 6000 kilowatts of Thomson-Houston alternators. The current is supplied at 55,000 volts, and conveyed 62 miles to Bordeaux, 28 miles to Periguex and 74 miles to Aledin Angouleme.

A movement has been set on foot by the English Ceramic Society for a conference of representatives of the various technical institutes and societies, to consider ways and means of arranging for the "grading" and standardizing, as far as possible, of the refractory materials, such as fireclay, magnesite, etc., used in the construction of furnaces, kilns and ovens.

Wave Motors and Windmills

By F. L. Johnson

One of the office boys asked me if I was too busy to see Mr. Sawyer this morning. Of course I am never too busy to listen to anything my young friend has to offer and he was admitted. Seating himself on the edge of the chair as a sort of an intimation that his visit was to be a short one, and refusing for the first time within my memory the cigar I offered, he said:

"I did not intend to come in at all this trip, as my time is limited, but I saw something on Broadway, near Thirtieth street, that carried me back to my childhood days. In a brilliantly lighted window I saw what was called a new wave motor; in general appearance it looked like one rather tall turbine wheel set inside another. The outer wheel was composed of carved slats intended to deflect the current of water which passed between them at a proper angle against the slats or blades of the inner wheel which revolved on an axis, as the old school books used to say.

"The sight carried me farther back to childhood memories than could even Wrigley's spearmint gum. It was a breath from the Illinois prairies where I was born. I went inside and talked with the man at the desk, who explained the construction and operation of the motor. He went into a whole lot of demonstration of the power that could be developed from a thirty-mile-per-hour wave or current, just as though the Coney Island surf rolled in all the time at an average rate of thirty miles an hour or more. And then he told me that the power of the wave varied as the cube of the speed, and said that with a sixty-mile wave eight times as much power could be developed as with a thirty-mile wave.

"He showed me photographs of a four-thousand-horsepower installation now under construction, with a windmill appendix intended to operate the machinery at a slightly reduced capacity in case there should come a few hours when there were no waves but plenty of wind. I intended to ask him whether storage batteries had been provided to keep up production in the event of a dead calm on both land and sea, but forgot it. I had not much time, so did not stay long, but came away with a pocketful of literature and blank applications for blocks of stock.

"While the man was telling me the usual promoters' stories of the wonderful progress of the last few years I almost had to ask him how he knew that forty years ago there were no looms or sewing machines; no typewriter and no Pullman cars. For I had seen a sewing machine that was built in 1840, a typewriting machine that was used in 1863, and the body of the martyred Lincoln was

transported to the West in a Pullman car.

"He showed me a copy of a letter from a man who said that President Roosevelt and Speaker Cannon were delighted with it and pronounced it, if successful, the greatest fuel-saver of the age. I remembered of reading somewhere about a machinist who made a machine to do a certain kind of work, and when the machine was done he showed it to all of the lawyers, doctors, preachers and school teachers that he could get to look at it, and they all pronounced it the work of a mechanical genius. But he never showed it to a mechanic because he knew what mechanics would think and say. I wondered a little if the same reason actuated the selection of politicians for trumpeters of the new motive power.

"But I am forgetting about my boyhood days. These were passed near a town in Illinois named Urbana, and the prairie around the village was dotted with windmills built, as nearly as I can remember, just like this new wave motor. From a distance one of these mills looked like a turret from the deck of one of Ericsson's monitors set up in the air on posts. The mill or rotor proper, as I recall it, was about 20 feet in diameter and 6 feet high, and as it revolved it operated a pump which supplied water for stock.

"One of my boyhood tasks was to take the place of the mill and operate the pump when the wind was not brisk enough for the work, and a part of my mischief was the cutting of short sticks from the osage or the willow hedges, which I used as a sort of 'trig' to place in a neighbor's mill to keep it from starting when the wind came. A little stick no bigger than my finger and a foot or so long, braced between a stationary and a moving vane, would hold the rotor from turning in a good stiff breeze, and my fun came from watching the irate farm-hand hunt for the cause of the stoppage of the motive power.

"The starting power of the mill was so small that I do not think it would take anything much stronger than a cotton thread to hold it from turning in a good stiff breeze. But these Western mills, although they looked, as I remember them, just like the new wave and wind motor, may be different. After I came East I saw a great many tide mills along the Atlantic coast, but one after another they have dropped out of sight and out of the field of economical power producers. One mill, I remember distinctly, had a pond of about 250 acres area and ground corn for the horses that drew the cars from one town to another. The cars are not drawn by horses now and the little cornmeal that comes to town is ground by steam where the corn is raised, and the old tide mill has gone to join the stagecoach in the collection of things our daddies used.

"I guess I won't stop to moralize. I would be glad to see heat, light and power made and transmitted by better methods than are now used, but I hardly think the shortest road to this end leads through obsolete windmill designs.

"I have some stray ideas on the future of power production, but time is too short today even to outline them, so I will leave them for a chat the next time I am in town."

Testing of a Three Phase Induction Motor

By F. H. Stacey

Nowadays, when the induction motor is used for such a wide range of service conditions it must frequently happen that the operation of such a motor becomes unsatisfactory for some reason or other. There are many causes for trouble which take some little investigation to reveal, but the chief trouble is excessive heating and consequent danger of charring the insulation, followed by the inability of the motor to carry its normal load. The question must then be determined whether the motor is capable of carrying its rated load. If not, and it is a new machine, of course it is up to the maker to fulfil his guarantee, but if it is overloaded, either the load must be reduced, or a larger motor put in; otherwise the smaller one may be permanently ruined by the continuous overload.

To decide this question of overload the rotor should first be examined to see whether the bars are all tightly screwed to the short-circuiting rings, and also whether the insulation separating the bars from the iron is in good condition. This insulation may have been burned by a temporary overload and only require renewing for the motor to run all right. While the bars are practically short-circuited to the iron the local currents generated in the rotor will be excessive and the power which should be used to drive the machinery will be largely wasted in heating the rotor, so that the motor will be able to transmit only part of its rated power to the shaft.

Supposing, however, the bars to be tight and the insulation in good condition, the only course open is a test to ascertain the actual work the motor is doing, by measuring the input in watts and the output in horsepower. For this are required a voltmeter, an ammeter and a wattmeter, and, depending on the voltage and current used, a potential transformer or series transformer, or both, may be needed. For controlling the circuits, two single-pole single-throw switches and a double-pole double-throw switch capable of carrying the full-load current of the motor are needed; also a small double-pole double-throw baby knife switch. With these appliances the tester should improvise a small portable switchboard which may be used for any motor up to 100 horsepower. As the majority of motors up to this capacity are operated on 550 volts, this is assumed to be the voltage in the present case, though by changing the transformer ratio and exercising more care with the insulation, machines of higher voltages may be tested in exactly the same manner. Arrange the switches on a board, as shown in the accompanying sketch, and wire up the meters as indicated.

Suppose, for example, that the motor to be tested is rated at 30 horsepower. The meters must be able to carry 40 amperes, or if they are of smaller capacity, a current transformer must be inserted in the line and the meters connected in the transformer secondary circuit. A convenient rule for finding the approximate current that a three-phase motor should require at 550 volts is to take the horsepower rating and assume that as the amperes per leg.

Or it may be worked out thus:

$$\frac{\text{Watts output}}{\text{Power factor} \times \text{volts} \times \text{efficiency} \times \sqrt{3}} = \text{amperes per leg.}$$

Example

A 30-horsepower motor with a power factor of 0.9, and an efficiency of 0.85:

$$\frac{30 \times 746}{550 \times 1.732 \times 0.9 \times 0.85} = 31$$

amperes per leg. The voltmeter and the potential lines to the wattmeter should be connected as shown in the sketch with transformers of 5 to 1 ratio, the voltmeters and wattmeters being constructed for 150 volts. Multipliers, if supplied with the instruments, may be used instead of transformers.

When the board is wired up, close the single-pole switches and open the double-throw switch until the motor comes up to speed, in order to avoid having the large starting current pass through the meters. When the motor has attained normal speed, put the load on and throw the central switch to one side; open the single-throw switch on that side and close the small switch in some direction to get the voltage between the third wire and the one in which current is being measured.

Read the volts, amperes and watts and record the readings; then throw the switches over to the other side and take readings again, being careful to get the voltage between the line connected to the meters and the third line, as before. Possibly, the wattmeter will read in the wrong direction, but all that is necessary to correct this is to transpose the connections of either the current or the potential circuit, but not both.

Having taken the readings in the two legs, add the watts and divide by 746. This will give the horsepower of input; and multiplying the input by 0.85, the as-

sumed efficiency, will give very nearly the power that the motor is delivering. An efficiency of 85 per cent. is assumed because this is a fair average for motors of this size, and the process of ascertaining the actual efficiency is hardly practicable outside a testing room or laboratory.

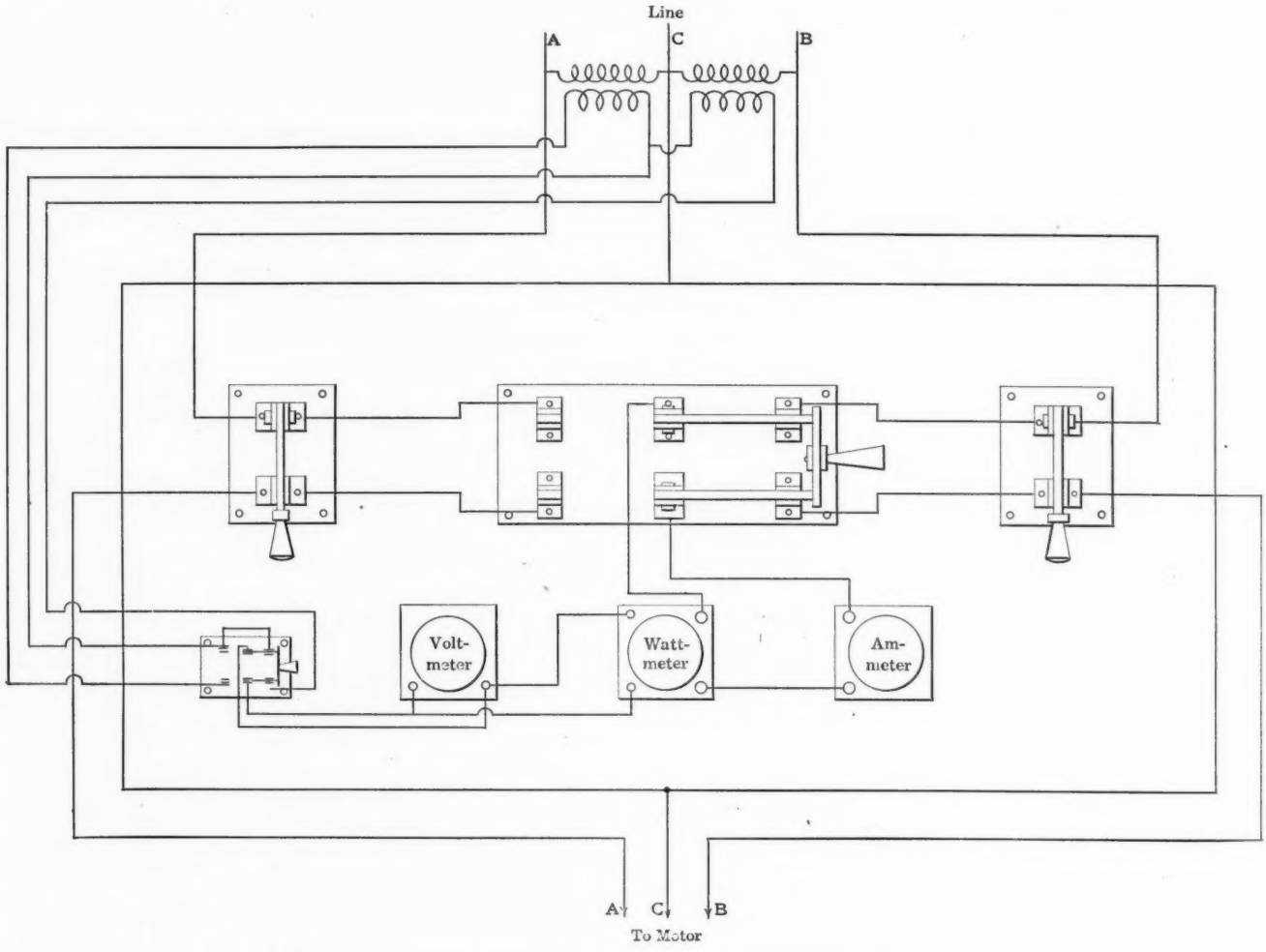
The next step is to multiply the average amperes by the average volts; multiply again by the transformer ratios, if any, and by $\sqrt{3}$; divide the watts by the final result and the power factor is obtained. If this is 0.85 or greater and the motor is fully loaded, it may be considered fairly satisfactory in this respect, though many motors of this size show as high as 92 or 93 per cent. power factor at full load.

The temperature of the iron of the stator should be taken by placing a thermometer in contact with the laminated core and covering the bulb with putty or a small wad of waste to screen it from the cooler air.

Take also the temperature of the air about 2 feet from the motor. The difference is the temperature rise, usually guaranteed by makers not to exceed 45 degrees Centigrade at full load. If the air temperature is 20 degrees Centigrade this would allow the motor temperature to reach 65 degrees and yet be within the guarantee. This is quite hot, too hot for the hand to be held long on the iron, but many motors run well up to 70 degrees Centigrade without injury to the insulation; inferior insulating material, however, would doubtless be injured in time by this degree of heat. If the temperature exceeds this and the motor is not overloaded the trouble may be caused by the machine being located where there is no circulation of air which, if remedied by ventilation, may remove the heating difficulty. To sum up, then, if the rotor insulation is good and the bars tight, and the temperature of the stator higher than 65 or 70 degrees Centigrade, the machine is either below standard in construction or is overloaded.

If the test shows the input to be more than 1.2 times the rating of motor, the machine must be of poor design, in bad condition, or else overloaded; if the latter, it should be replaced by a larger motor as soon as possible, or the load reduced to suit the motor.

In these days of high-speed machinery there may be a difference of as much as 5 per cent. in the efficiency of an engine by using an inferior grade of oil.



WIRING OF SWITCHES AND METERS FOR TESTING THREE-PHASE INDUCTION MOTORS

Blowing Soot Out of the Boilers

C. J. Larson, chief engineer of the Union Electric Company, of Dubuque, Ia., has rigged up a simple device to blow soot out of the combustion chambers of the boilers without cooling the boilers down. A 1½-inch pipe leads from the main steam riser between the boiler and the main steam header, down the side of the boiler and enters the combustion chamber. The boilers are Babcock & Wilcox type and the soot rapidly collects back of the furnace, the trouble probably being augmented because of the fine grade of coal burned at this station. The end of the pipe within the combustion chamber is fitted with a spray nozzle. By opening a check valve, the steam enters the pipe at about 190 pounds pressure and 125 degrees of superheat, entering the chamber in a strong blast which effectively loosens the soot from the floor and side walls and blows it up the stack. By using the steam blast for five minutes every week or two, the combustion chamber is kept entirely free from soot. Without the blast it would be necessary to shut the boilers down at frequent intervals for cleaning.

—*Electric Traction Weekly.*

High Pressure Steam Piping Systems

Some Notes on Recent Design, Including a Discussion of Expansion, Vibration, Pipe and Pipe Fittings, Joints, Separators and Valves

BY WILLIAM F. FISCHER

In laying out a piping system the designer should aim to do away with all unnecessary piping, and carry his lines as direct as possible, making proper allowance for expansion and contraction. The piping should be dripped wherever necessary, and all water of condensation returned to the boilers. Where the piping is carried through a wall or floor, what is known as pipe sleeves or thimbles should be built in around it. The inside diameter of these thimbles should be greater than the outside diameter of the pipe flanges to allow for the removal of the pipe when necessary. A steam pipe should never under any circumstances be built rigidly into the walls of a building, as the expansion strains or vibration in the line are almost sure to loosen the wall in time. A piece of pipe of the proper diameter and length with a plain-faced, undrilled flange at each end is a good substitute for a cast pipe thimble, although if a number of the same size are to be used, the casting will be found to be the cheaper of the two.

No definite rule can be given for the arrangement of steam lines, for the conditions met with in different stations vary greatly. As a general rule, however, in most of the modern power houses of today, no main steam header is being used larger than 14 inches inside diameter, or, as they are designated, 15 inches outside diameter. The station is subdivided into complete and independent units, the piping being so arranged that the boilers feed the main steam header uniformly, or nearly so, throughout its length, and provision is made to feed the engines or turbines in a similar manner. In this way each unit is taken care of by a certain number of boilers, the header being divided up into sections by the use of gate valves so placed that any section of the header may be cut out of service for repairs if necessary without interfering in any way with the successful operation of the station, or, in other words, by closing valves in the main steam header, each unit is made entirely independent of the others. In some cases a valve is placed in the main steam header between each connection to or from the header. Steam to the auxiliaries is taken direct from the main steam header, or from a separate auxiliary header. Where it is desired to use superheated steam for the main engines and saturated steam for the auxiliaries, a separate header and separate boiler connections are required for each case.

The elaborate system of duplicating steam mains and connections is not necessary to a good design, although on rare occasions the designer may find it an advantage. Some few years ago, in order to overcome deficiencies in valves, fittings and workmanship, and also to insure greater reliability, the duplicate system was introduced and became a fad for awhile, but seeing the steam gages in the larger stations stand at from 200 to 250 pounds, and still indicating a tendency to creep higher, the manufacturers did a little figuring, and as a result they are today, and have been for the past few years, meeting the demand with all necessary materials for a first-class single piping system. As a consequence, the duplicate system is rapidly becoming a thing of the past. Reliability is better insured by the careful design of all valves and fittings, combined with the use of higher grade materials and superior workmanship. The judicious placing of cutout and bypass valves, properly providing for expansion and contraction, locating separators and drip pockets where necessary and trapping all water of condensation back to the boilers as fast as it forms, will result in a system far superior to the elaborate and expensive duplication of the past.

Valves

Two valves should be placed in a line connecting a battery of boilers with the header. One of these valves should preferably be an automatic stop and check valve placed at the outlet of the boiler, and the other a gate valve placed next to the main steam header. There should also be a valve in each connection from the header.

As globe valves introduce considerable friction and form water pockets in the line, they are seldom, if ever, used on a good job, except as throttle valves placed next to the engine or pump cylinders.

Gate valves over 6 inches in size should be provided with bypass connections, to enable them to be easily opened by equalizing the pressure on both sides of the gate, also permitting steam to be admitted slowly into the cold end of the line, warming it up gradually. This prevents water hammer, and also distributes the expansion strains more uniformly throughout the piping system.

All gate valves 6 inches and larger are, as a rule, specified: outside screw and yoke, with stationary handwheel and rising stem. With this type the rising stem shows at a glance the approximate position of the gate or disk. These valves are furnished with indicators graduated to show the exact opening at all times, if so specified when ordering. The threaded stem being outside the stuffing box, does not come in contact with the hot steam, and is therefore easily lubricated. If desired to operate the valve from the floor line or other accessible position, the stationary handwheel may be replaced by a system of gearing with a return extension stem and handwheel carried to the desired position.

Expansion

The average main steam header, unless firmly anchored, has a tendency to creep or move out of position parallel to the length of the line. This is due to the expansion and contraction strains set up in other branches of the system, and also to vibration. The header should be firmly anchored to prevent as far as possible this shifting of position, as it strains the joints in the connections to and from the header, and also to steady the piping against vibration. In piping of any length proper provision should always be made to take up or relieve the expansion strains in that section, to prevent the straining of the joints, which is almost sure to cause leakage or perhaps rupture at the weakest point. Where a pipe line is anchored or fixed at two points, an expansion bend should be installed in the line somewhere between the points, as no ordinary anchor or fastening will resist the force of expansion, and if they did the strain would fall on the joints.

Steel pipe bends of long radius are used in preference to cast elbows of short radius, as they reduce the number of joints in the system and insure greater flexibility throughout. Where possible, all bends should be curved to a radius of not less than six pipe diameters, a greater radius being preferred in all cases where the expansion strains are severe.

Bends can now be made from pipe 40 feet or more in length if necessary. This is accomplished by welding two or more pieces of pipe together, either before or after bending. Expansion bends made from pipe greater than 10 inches in diameter are necessarily much stiffer than bends made up from the smaller sizes,

and as any distortion of a bend beyond a certain stage leads to high strains on the joints, this stiffness should be taken into account when designing. A thorough knowledge of the effects of expansion on the piping system is essential to every engineer, and the writer feels he can do no better than to refer the reader to the June 2 and October 20, 1908, numbers of POWER AND THE ENGINEER, where the subject is covered to some length.

VIBRATION

Steam flowing at a velocity of from 5000 to 6000 feet per minute in the supply pipe of a modern high-speed engine, is alternately stopped and raised again to this velocity several hundred times a minute, due to the quick opening and closing of the steam valves. This intermittent motion of the steam in many cases causes vibration and hammering in the supply pipe, which in turn is transmitted to other branches of the piping system. Vibration is also caused by suddenly changing the direction of the steam flow through short-turn elbows or tees, and also to an unequal velocity of the steam flowing through different branches of the system. Where possible to do so, the pipes should be so proportioned that the velocity will be as near uniform as possible in all branches to and from the main header.

In one case of the writer's knowledge, a vibrating pipe line was anchored at a certain point. This decreased the vibration to a large extent, but no provision was made to take up the expansion in that section of the piping between the anchor and the boiler nozzles. The plant was shut down each night, and started up again early each morning. In about a week's time the joints in the piping farthest away from the anchor were found to leak badly. They were repacked with new gaskets and made up steam-tight, but about a week later were leaking almost as badly as before. The engineer-in-charge, being a practical mechanic, at once decided that the anchor was causing the trouble, as these leaks had not occurred before the anchor was placed in position, so in place of wasting more time and material in repacking the flanges, he decided to investigate, and soon found the cause of the trouble. It appears that the anchor, which was very rigid, was installed while the line was hot and the piping clamped firmly in position. The expansion in this line was found to be nearly 1⅞ inches; consequently at night when the plant was shut down, the line shortened, throwing a heavy strain on the pipe and bolts at each joint and causing the leakage.

The engineer removed a section of the piping and installed an expansion loop of long radius. He decided it would be better to throw part of the strain on the piping while cold, so the bend was sprung into position. The next morning steam was turned on as usual, and there was no more trouble from leakage or vibration.

SEPARATORS

A large "slug" of water is not a very healthful "dose" for a steam-engine cylinder, especially in high-speed engines where the clearance space between the cylinder head and piston is reduced to a minimum. In all modern work each engine supply pipe is usually equipped with a separator of large volume, placed as near the engine throttle as possible, and all main steam headers are equipped with drip pockets.

Besides intercepting the moisture in the steam the separator performs another function of great value, in that it provides a reservoir where the steam is stored after the steam valves close at each stroke of the engine piston. This insures a more uniform pressure in the engine cylinder up to the point of cutoff and also provides a cushion of steam near the engine cylinder to take the reaction caused by the quick cutoff in the steam chest, thus preventing vibration from being transmitted to the piping system.

Separators also tend toward a continuous and steady flow of steam in the direction of the engine instead of the otherwise necessary stopping and starting of the flow with every movement of the engine valve, in this way preventing to a large extent the usual drop in pressure between the boilers and the steam chest, also reducing the tendency of the boilers to prime during a momentary excessive demand.

Separators having a capacity of from three to four times that of the high-pressure cylinder are making it possible in many cases to reduce the size of the engine supply pipe, up to the inlet side of the separator, from 5 to 15 per cent. over that called for by the engine builders, the piping between the separator and the engine remaining the same size as called for.

This last rule does not seem to apply to separators where used in connection with steam turbines, as the velocity is much higher and more uniform throughout. The piping should therefore be of full size throughout its length, from the main steam header to the throttle inlet. Separators of the receiver type are preferred.

Mechanics are sometimes careless in erecting new work, leaving bolts, nuts, wrenches, cold chisels, oil cans, etc., inside the piping. The operating engineer comes across this junk some few week later in a place where only an engineer would ever expect to find such things. Small junk, unless stopped by a separator, eventually locates in the engine cylinders, scoring and cutting them so badly that in many cases they have to be rebored. A small bolt or nut going over with the flow of steam would rip the blades from a steam-turbine rotor, owing to the small clearances between the blades and casing. For this reason the turbine supply pipe is nearly always equipped with a net or strainer to stop such junk before it reaches the turbine inlet. These strainers are furnished with the turbines.

Loose junk remaining in the piping system after erection also has a tendency to come to rest directly under the seats of stop valves, making it impossible to close them. A good separator will remove nearly, if not all of this small junk before it could reach the engine cylinder, and prevent injury to the interior parts, or even engine wrecks.

PIPE

Wrought-steel pipe, especially in the larger sizes, is preferable to wrought-iron pipe for general use. As ordinary commercial pipe may vary in thickness from the standard, as listed in catalogs, "full-weight pipe" should be specified. As a rule full-weight pipe will be found to run full card weight, but should never vary more than 5 per cent. either way.

Full-weight pipe of steel or wrought iron is suitable for working pressures up to 250 pounds per square inch, if not reduced in thickness by threading outside the hub of the flanges. For bending purposes lap-welded steel pipe is better than butt-welded, as the seam is less liable to open up under the stress of bending to a short radius. For threaded joints, if sharp dies are used, steel pipe has been found to cut and thread as readily as wrought-iron pipe, but blunt dies have a tendency to tear or break the threads.

Where used in connection with Van Stone joints or joints where the pipe is turned over the face of the flange, wrought-iron pipe has been found to split badly, both at the weld and all around the outer circumference when rolling or flanging over. Steel pipe is better in all cases, and open-hearth steel pipe is preferred to bessemer steel, both for Van Stoning and welding purposes, as the quality of the metal is more uniform and low in carbon.

The following tests, taken from a Crane catalog, will serve to demonstrate the strength of steel pipe as compared with wrought-iron pipe. The pipe was picked from stock at random:

Ten-inch standard wrought-iron pipe burst at 1900 pounds; 10-inch extra-strong wrought-iron pipe burst at 2700 pounds; 10-inch standard wrought-steel pipe burst at 3000 pounds.

None of this pipe burst at the weld, but some distance from it, showing the weld to be in this case at least as strong as the pipe itself. Extra-strong and double-extra-strong pipe is used more in hydraulic work, for turbine step-bearing oiling systems or boiler-feed lines, than for steam.

PIPE JOINTS

Many of the earlier stations are using screwed or threaded joints in their steam mains successfully where the pressure is 150 pounds or even greater. In many

cases, extra-heavy pipe is used in connection with the screwed and peened joint, where the end of the pipe is peened or rolled into a recess at the face of the flange to prevent leakage through the threads, and to prevent the loosening of the flange at the threads. This is a good joint if properly made and is still used quite extensively in new work. For pressures above 150 pounds and for superheated-steam work the general tendency is to specify either the Van Stone or welded type of joint in sizes 5 inches in diameter and larger, the screwed or screwed and peened joints being used only in the smaller sizes.

There seems to be one objection to the old type of Van Stone joint, in that the turned over or flanged portion of the pipe is thinned down considerably in rolling and finishing the face of the joint, making this the weakest point, as shown in Figs. 1 and 2. In the first illustration the dotted lines *C* show the position of the pipe before rolling. Line *A A*, slightly exaggerated for clearness, shows the bevel of the face of the joint after rolling, due to the gradual thinning down of the metal to the edge *B*, which is due to the stretching of the metal on the outer circumference of the flanged portion. Fig. 2 shows the same joint after the face has been finished off true in the lathe. Note the thinning down of the metal at *D* as compared with *T*, the original thickness of the pipe.

To overcome this defect joints known as the "Cranelap" and "improved Van Stone" were put on the market some years ago, and are now used in preference to the old type. The method of constructing the Cranelap joint is shown in Fig. 3. At *E* the face of the flange is shown beveled inward to compensate for the difference in the thickness of the pipe between the inside and outside portions of the lap. This brings the face of the joint almost true after rolling, a light cut being all that is necessary in facing.

The improved Van Stone joint is made by securely welding a tapering band of steel to the end of the pipe around the outer circumference as shown in Fig. 4. Fig. 5 shows the same joint after rolling and facing. The flange is bored out to a slight taper, as shown at *G*. The thickness of the pipe *F* at the face of the joint is greater after finishing than the original thickness *T*.

Both of these joints are being used extensively for superheated-steam work. The flanges on all joints of the Van Stone type are loose and swivel on the pipe, a fact appreciated by erecting engineers, as it is sometimes necessary to change the position of bolt holes in the field.

Another joint coming into use for high pressures is the welded joint, made by welding a wrought-steel flange direct to the end of the pipe. Fig. 6 shows what is known as the screwed-and-peened joint. The pipe is screwed into the flange steam-tight, leaving a short length projecting beyond the face of the flange. This end is then heated and either rolled or peened over, filling the recess *H* at the face of the flange. The flange is then faced off true in the lathe and drilled. This is a good joint if properly made, and is much superior to the ordinary screwed joint, which is too well known to require any description.

Flanges

Cast-iron and cast-steel flanges are sometimes used in connection with the Van Stone and similar joints, but in all cases a good rolled-steel flange is to be preferred. The cast-steel flange in many cases costs nearly as much as the flange of rolled steel and is far inferior, as the metal may not run uniform throughout. The writer has seen cases where cast-steel flanges in the rough looked sound and perfect in all respects, but upon facing and drilling were found to be honeycombed with blowholes beneath the surface, and as a consequence were rejected. Blowholes can be entirely prevented in steel castings by the addition of manganese and silicon in sufficient quantities, but both of these elements cause brittleness and should be added with caution on this account.

Gaskets

The gasket might be called the connecting link of the piping system, and is of more importance than would appear at first thought. Much trouble has been experienced in an otherwise perfect system of piping, due to the gaskets alone. The cost of renewing gaskets is an important item and should not be overlooked. First it is necessary to shut off pressure on that part of the line, open the joint, scrape and clean the face of the flanges, insert the new gasket and make up the joint again steam-tight. From two-thirds to three-fourths of the actual expense of renewing a gasket under favorable conditions is for labor alone, and shutting off pressure from any one section will probably mean shutting down one or more units, boilers or engines as the case may be.

There are many different ways, too numerous to mention here, of forming the face of flanges to prevent the gasket from blowing out. With flanges of the tongue and groove, or male and female type, it is necessary to spring the pipe apart at the joints to remove the old gasket and replace the new one, and at times this cannot be done without taking down a section of the piping. The straight-face joint, if properly put together with a good gasket suitable to the work, will stand a test of 1000 pounds without blowing out.

On Van Stone work a ground joint is quite often used without a gasket, that is, the face of the joint is ground in oil to a fine finish. This is much more expensive than a joint having a fine tool finish, and made up with a gasket. The corrugated-copper, corrugated soft swedish steel, and gaskets of long fiber-woven asbestos capped or covered with copper or bronze all seem to give excellent service for all pressures and temperatures. Other gaskets containing rubber or alloys of soft metal are quickly destroyed if used in connection with superheated steam.

Welded Steam Headers

The latest practice among engineers is to do away with fittings in the main steam lines entirely and substitute what is known as the welded header, where piping up to 40 feet or more in length is welded into one piece, and all nozzles or outlets welded directly to the header itself. The piping will have 10 to 15 per cent. less strength at the weld in many cases, unless reinforced at this point. One of the large concerns doing this class of work makes the metal at the weld from 50 to 300 per cent. thicker than the pipes,

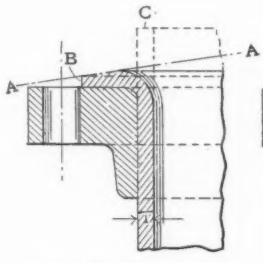


FIG. 1. Van Stone Joint Before and After Rolling.

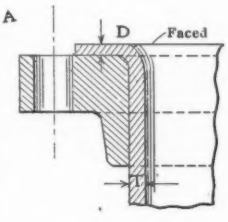


FIG. 2. Van Stone Joint after Facing True.

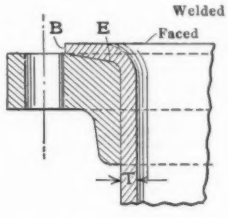


FIG. 3. Cranelap Joint after Rolling and Finishing.

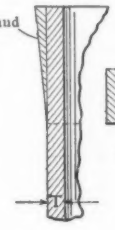


FIG. 4.

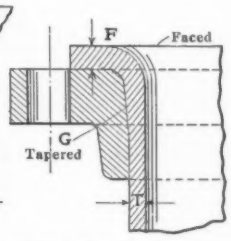


FIG. 5. Improved Van Stone Joint after Finishing.

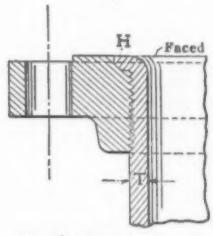


FIG. 6. Screwed and Peened Joint.

to insure the joint being stronger than the pipe itself. With the welded header, rolled-steel or cast-steel flanges may be used in connection with Van Stone or similar joints, or if preferred, the welded joint, having all flanges welded to the pipe.

Some advantages of the welded header are: The lightening of the entire work, better quality of material used, decreased number of joints liable to leak and the saving of time, labor and expense in erecting. There seems to be one objection to the welded header, however, in that it is difficult to make a new connection to the header if required to do so after the piping is installed. This difficulty can be overcome by allowing one or two extra nozzles when making up and blanking them with a blind flange until needed.

Fittings and Valves for Superheated Steam

Cast iron does not seem to stand up to its record under the action of superheated steam as well as it has been doing with saturated steam, as several tests made after a few years' service show quite a reduction in strength. The following case is copied from Power and The Engineer, November 24 number: A 20-inch tee recently removed from a superheated-steam line, after three years' service under a pressure of 160 pounds per square inch, with 125 degrees of superheat, making the ultimate temperature less than 500 degrees Fahrenheit, showed cracks open as much as ⅛ inch on the outside, through which steam leaked. The casting was nearly ¾ inch longer and 1 inch greater in diameter than when installed. The inside surface was found covered with a hard, reddish oxide, with no cracks visible.

The Crane Company recently cited a case showing where a 14-inch cast-iron high-pressure gate valve, after four years' service in a superheated-steam line, showed a loss of strength of 49 per cent. in the material in the body of the valve, and 33⅓ per cent. in the material in the flanges. The steam pressure in this case was 200 pounds per square inch and steam temperature 590 degrees Fahrenheit. The valve was found to be 5/16 inch longer than when installed.

As a general rule for all superheated-steam work and for high temperatures, fittings and valves are specified to be of cast steel.

Making Ice Cream in a Large Ice Plant

By John N. Swartzell

On August 4, last, the Chapin-Sacks Manufacturing Company, of Washington, D. C., held a formal opening of one of the most uptodate and sanitary ice-cream factories in the country. For many years this company has operated a large ice-manufacturing establishment and only comparatively recently has been making plans and preparations for the erection of the ice-cream factory which is now run so successfully in connection with the ice-making business. The company's buildings, which occupy the entire eastern end of the block between North Capitol, First, Patterson and M streets, northeast, are two in number and are located conveniently with respect to the Union station and the tracks over which the milk arrives.

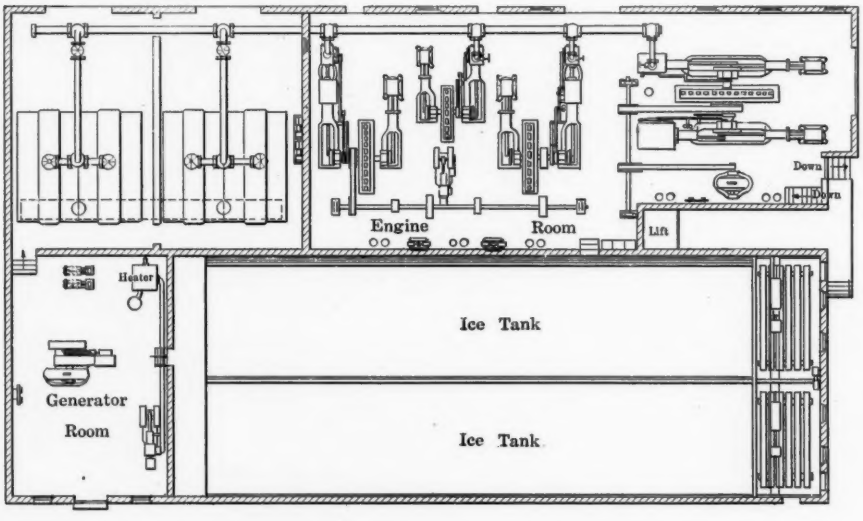


FIG. 1. PLAN VIEW OF ICE PLANT

Methods of Handling Milk

Milk used at the plant is delivered in refrigerator cans and cars from Jefferson county, New York, and is chemically tested before being used. Upon arriving at the factory it is carried to the second floor of the building and placed in a cold-storage vault until ready for pasteurization and mixing prior to being made into ice cream. Next to the storage room and communicating with it is the mixing room. This room contains the pasteurizer and the mixers. The pasteurizer heats the milk to a temperature of 175 degrees Fahrenheit, then cools it down by water to 75 degrees Fahrenheit and finally reduces its temperature to 38 degrees Fahrenheit by cool brine.

There are four machines for mixing the ingredients of the ice cream. These are huge galvanized-iron tanks, each having a capacity of 150 gallons. In the center of each tank there is a vertical shaft fitted with two dashers, these being arranged to revolve in opposite directions, and the shaft supporting them is driven by a bevel gear and shaft from a Crocker-Wheeler 110-volt direct-current motor. The mixers are set in two groups, one motor sufficing to operate each group. The driving shaft is divided and furnished with a clutch so that the mixers can be run singly when desired.

Located on the first floor of the building directly under the mixing room is the freezing room. There are six horizontal and one vertical freezer, each having a capacity of 12 gallons. The freezers are cooled by brine circulated by a small centrifugal pump, which is located in the mixing room, and is direct-connected to a 3-horsepower direct-current motor having a speed of 1650 revolutions per minute. The cream to be frozen flows by gravity from the mixing tanks to the freezers through pipes put up in short sections, so arranged that they may be taken down each day and thoroughly washed. The horizontal freezers are equipped with individual 1½-horsepower Crocker-Wheeler direct-current motors, while the vertical machine, used only for freezing fancy creams, is driven by a Lincoln 2-horsepower variable-speed motor. Each motor is connected to its respective freezer by a noiseless chain-and-sprocket drive.

The freezers are elevated a sufficient distance from the floor to permit the frozen cream to be drawn off by merely opening a valve, placed conveniently in one end. Cream upon being drawn from the freezer is placed in the hardening room, where it may become firm, and allowed to remain there until ready for shipment. For the purpose of crushing the ice used in packing the frozen cream for delivery, two motor-driven ice crushers are installed, one emptying directly into the shipping department, the other discharging into a chute through the outside wall of the building for filling the delivery wagons. Ice to be crushed is carried to the second floor of the building from the ice-storage room on the first floor by an ice hoist driven by a General

Electric 115-volt direct-current motor. Here it is dumped into a chute and delivered to the crushers.

Adjoining the freezer room is the washing and sterilizing room. The cans upon being returned by customers are brought to the rear of the building and received through a small doorway for that purpose and placed in the tubs, where they are thoroughly washed. After the process of washing is finished the cans are placed in a wire basket moving upon a track and passed into a steam sterilizer. The sterilizer was built and installed by the Kensington Engine Works, of Philadelphia, Penn., and resembles in appearance a small horizontal boiler, being about 8 feet long by 4 feet in diameter. The method of operating is as follows:

Steam at 80 pounds pressure is admitted to the reducing valve and the pressure lowered to 10 pounds. At this pressure it is permitted to enter the jacket surrounding the internal chamber. When this has been accomplished the chamber is ready to receive the material to be sterilized. After the temperature of the chamber has risen considerably the air exhauster is opened until the vacuum gage shows 15 inches of vacuum. The valve to the inner chamber is then opened slightly, and when the pressure has risen the valve is closed and the air exhauster again started. When the vacuum gage indicates 15 inches the steam valve is again opened until the thermometer reads 238 degrees Fahrenheit. The steam is then allowed to circulate through the chamber for a short time, after which it is shut off and the exhauster opened once more to draw off the steam and vapor. In a few moments, when the heat of the jacket has had an opportunity to dry any moisture remaining inside the chamber, the doors may be thrown open and the contents of the basket removed.

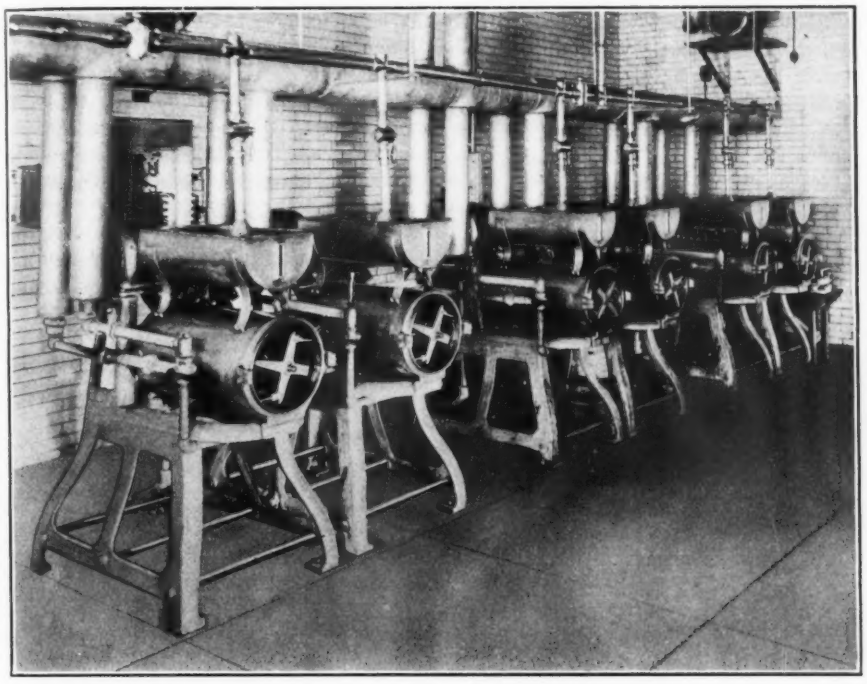


FIG. 2. FREEZER ROOM

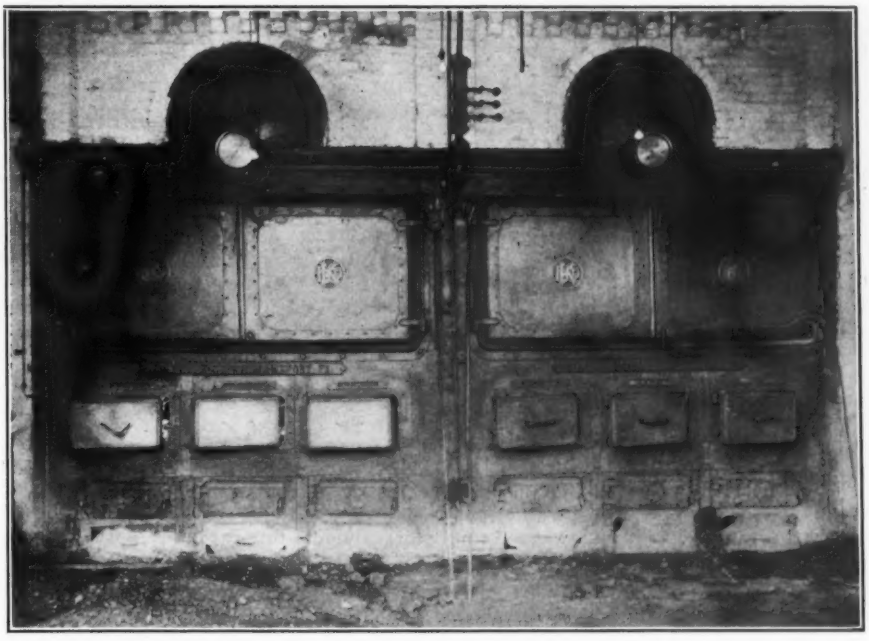


FIG. 3. BOILER INSTALLATION

Ice Plant

The plant of the company is fitted with five ice tanks, each 95 feet long, 20 feet wide and 10 feet deep for manufacturing plate ice, the direct-expansion system being employed. The sheets of ice, averaging six tons in weight, are removed from the tanks at intervals by an overhead traveling crane. Six and one-third days are required for an entire freeze. The cranes for handling the huge sheets of ice are operated by a hydraulic pressure of 150 pounds, maintained in tanks by small simplex steam pumps located at the farther end of each room, one sufficing to operate the cranes of two tanks.

The sheets of ice, of which there are about 70 to each tank, are cut up into blocks by means of an iron frame heated by steam. As the blocks are cut they are placed in a chute and slid into the ice house. During the summer season the total output of the plant is 230 tons per day, and in winter it varies between 60 and 70 tons per day.

There was once a time when plate ice could not be manufactured from anything but distilled water, but this difficulty has in later years been overcome by circulating air at low pressure through the ice tanks during the process of freezing. The circulator employed at this plant was built by the Bury Air Compressor Company, of Erie, Penn., and is located in a small room in the older part of the building, which also contains the boiler feeders, the heater and an electric-generating unit. This unit consists of a Buckeye simple heavy-duty high-speed engine and a Sprague 50-kilowatt 110-volt direct-current generator. The circuits supplied by the generator are controlled by a one-panel switchboard located nearby, using Weston instruments and furnished by the Trumbull Electric Manufacturing Company, of Plainville, Conn.

The boiler feeders consist of two Knowles outside-packed plunger pumps,

sizes 7½x5x6-inch and 7½x5x10-inch, respectively. These, as well as the compressor and generator engines, exhaust into a Cochrane open heater which raises the temperature of feed water to 210 degrees Fahrenheit before delivering it to the pumps.

Located next to this room and communicating by means of a low arched doorway is the boiler room, which is 48 feet long by 41 feet wide and is divided into two parts by a brick partition, one room being 41x23 feet and the other 41x25 feet. The larger room contains two 250-horsepower boilers fitted with Hawley down-draft furnaces. In the other room are located two of 228 horsepower each. The entire boiler equipment was furnished by the E. Keeler Company, of Williamsport, Penn., and was built to carry a working pressure of 160 pounds. The boilers have one steam and water drum 20 feet 5 inches in length by 48 inches in diameter, contain one hundred and thirteen 18-foot tubes 4 inches in diameter, and are fitted with horizontal baffles. In addition to the feed pumps located in the generator room there is another battery in the larger section of the boiler room, comprising two Snow duplex pumps, size 5¼x3½x5 inches. These are held in reserve. The waste gases are conducted to the atmosphere by a rectangular uptake and two steel stacks.

West of the boiler room in the same building is the engine room containing four Corliss-driven ice machines. These were built by the Vilter Manufacturing Company, of Milwaukee, Wis. There is one 125-ton machine, consisting of two 18x36-inch double-acting ammonia compressors driven by a 400-horsepower cross-compound condensing engine; two machines of 55 tons capacity, each consisting of one 17x34-inch ammonia compressor operated by a tandem compound-condensing engine, and one machine of 10 tons capacity operated by a simple non-condensing engine. On the cross-compound an automatic oiling system keeps the bearings flooded, oil being pumped from reservoirs under the base of the engine by a small pump operated from the rocker arm of the low-pressure eccentric. The bearings of the other engines are arranged for oil-cup lubrication, while the cylinders are furnished with Phoenix force-feed oil pumps driven from the wristplates. All the engines have heavy-duty frames, and with the exception of the simple engine are belted to a line shaft. The 400-horsepower unit drives an overhead line shaft which in turn is belted to a Westinghouse 30-kilowatt 125-volt direct-current generator. On the wall of the engine room there are gage panels indicating steam, receiver, ammonia head and back pressures as follows: Steam, 135 pounds; receiver, 15 pounds; ammonia head pressure, 210 pounds; ammonia back pressure, 18 pounds.

The ammonia condensers are of the countercurrent type and are located in a covered area upon the roof of the old building. These are two in number and are composed of 24 coils of 2-inch pipe, 24 pipes to the coil and 22 feet long. For the raising of condensing water over the cooling towers, a Goulds triplex power pump is employed and is driven by a belt from a line shaft in the engine room, which also drives the fans of the cooling towers. The two cooling towers, located above the condensers, are built of wood and are each equipped with two 60-inch fans. The steam condensers in connection with all three of the ice machines are of the counter-barometric type and are supplied with water which has previously been used for condensing purposes in the ammonia condensers. They are located on the roof of the building containing the engine room.

There are three vacuum pumps on the condensing system. Two of these are located in the engine room and the other in the basement. The two in the engine room are small horizontal flywheel pumps for wet-vacuum service, while the third is a dry-vacuum pump.

For the information contained in this article the writer is indebted to A. A. Chapin, president of the company, who cordially invites public inspection of the plant.

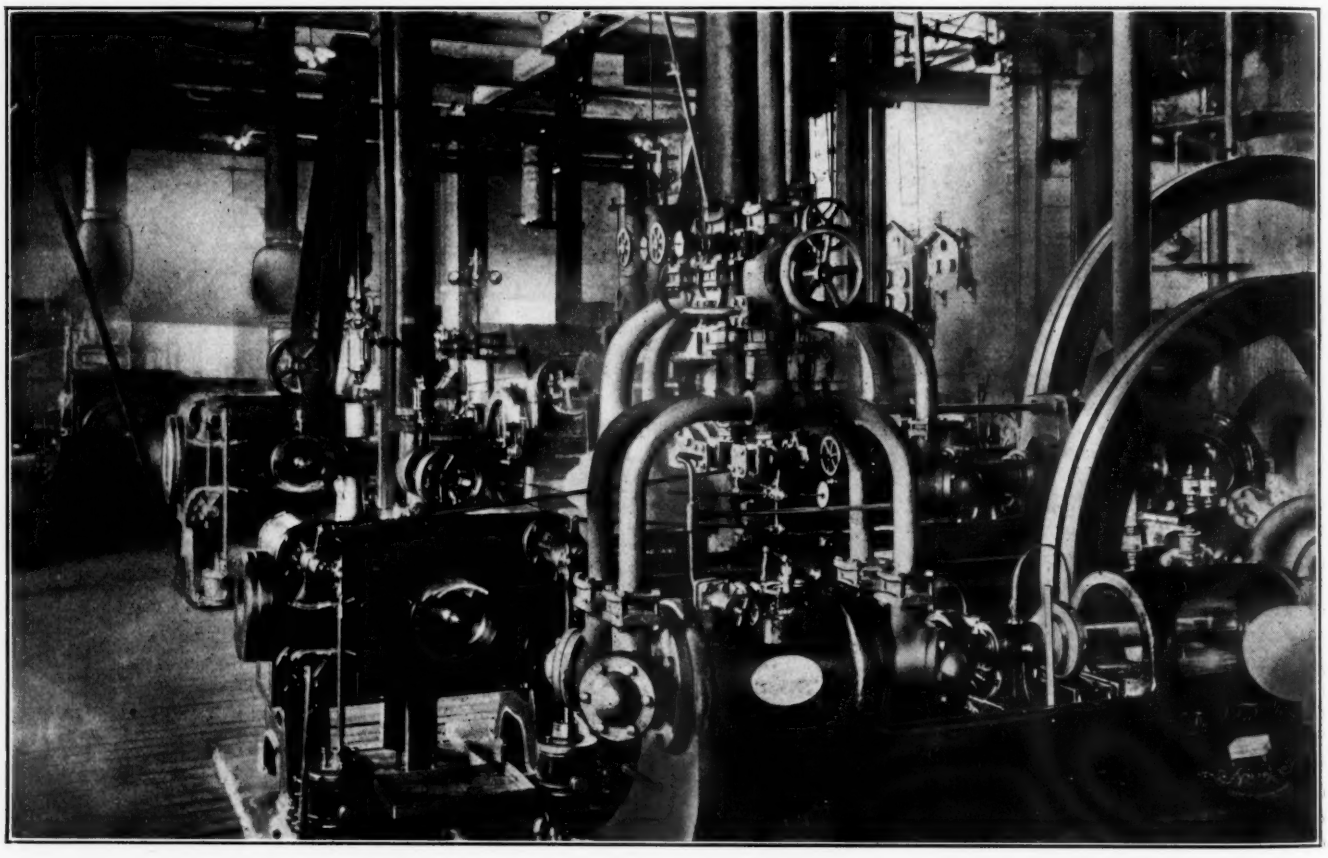


FIG. 4. ENGINE ROOM

Modern British High-Speed Steam Engines

Description of What Is Believed to Be Practically the Only Single-Acting Compound Engine Built in Numbers in England; Other Makes

BY JOHN DAVIDSON

Allen. Another firm which makes a specialty of high-speed engines is that of W. H. Allen, Son & Co., Ltd., of Bedford, England. The company's design of two-crank compound engine is illustrated in Fig. 20. This engine differs somewhat from those already described, as flat guides of marine type are provided in place of bored ones. These are formed in the back of the frame and not as an extension of the distance piece carrying the cylinders. Again, the distance piece supporting the cylinder from the main frame of the engine is cast in one with the cylinders. This does away with the necessity of a joint underneath the cylinder, but somewhat complicates the cylinder casting. The two cylinders are also placed side by side and the valves on the outside. By this means the cranks are brought closer together and probably a slightly better balance is obtained.

The design of triple-expansion engine manufactured by this firm is shown in Fig. 21. Details of construction of the engine are similar in most respects to those of the two-crank compound engine. The piston valves are formed in one solid piece in the form of a tube, no rings whatsoever being fitted. The loose ends are arranged for driving as shown, and by fitting these ends, the valve can be made of uniform shape and thickness and distortion due to alterations of temperature entirely prevented.

An exterior view of a standard three-crank triple-expansion engine of 600 kilowatts capacity is illustrated in Fig. 22. One very noticeable feature is the size of the doors which are provided to give access to the working parts.

Reavell. Practically the only single-acting engine which is manufactured in any number is the Reavell engine which is made by Reavell & Co., Limited, of Ipswich.

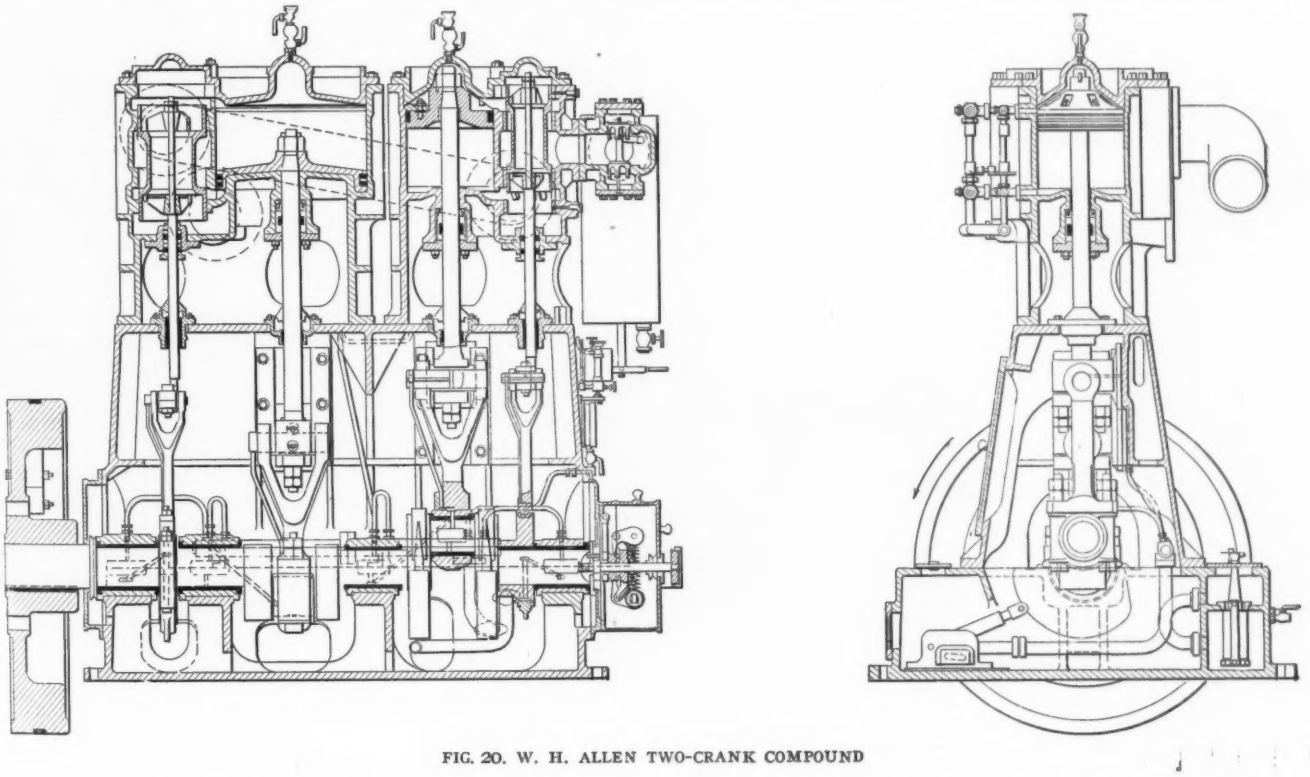


FIG. 20. W. H. ALLEN TWO-CRANK COMPOUND

The construction of this engine is shown in Fig. 23. In a compound or two-stage expansion engine the second stage is usually obtained by transferring to a larger cylinder the steam which has just completed its first stage of expansion in the smaller, or high-pressure, cylinder. The same effect, however, can be obtained by transferring only a portion of the steam which is already expanded in the first cylinder, in which case the second cylinder may be of the same size as the first cylinder, and the portion transferred will be farther expanded in the second cylinder; the portion remaining in the first cylinder being utilized as will be described later. The first cylinder would be equivalent to the high-pressure cylinder, and the second cylinder to the low-pressure cylinder in an ordinary compound engine. This latter method is adopted in the Scott compound engine, the only difference being that instead of employing two cylinders, the first stage of expansion takes place on the top of the piston and the second stage on the bottom of the piston in one cylinder.

The cycle will be made clear by reference to the theoretical diagram shown in Fig. 24. Steam is admitted at *W* into a cylinder having a considerable clearance volume above the piston at the beginning of the stroke. This clearance volume is already filled with steam at boiler pressure, having been compressed during the latter part of the preceding stroke. Cutoff takes place at *X*, the actual point being varied by the governor to suit the variations of load. The total steam in the cylinder, which includes that already in the clearance space at the beginning of the stroke, then expands during the remainder of the down stroke to *Y*. As the piston is turning the bottom center a communication is opened between the top

and the bottom of the cylinder, which remains open to *Z*, transferring a portion of the steam to the under side where its second stage of expansion takes place, until the termination of the up stroke, just in the same way as it would do if transferred or exhausted to a separate cylinder.

The steam which remained above the piston at the point *Z*, when the communication from the top to the bottom of the cylinder was closed, is compressed up to initial pressure *W*.

Referring to the sectional illustrations, Fig. 23, it will be seen that the steam-inlet flange is on the body of the cylinder itself, there being a steam jacket of considerable size between the working barrel and the outside of the cylinder, and between the inner and outer cover. The valves of the engine reciprocate in a central valve liner secured in the bottom of the cylinder as shown, and the piston reciprocates in the annular space between this liner and the cylinder walls. The steam, entering through the stop valve, passes up between the inner and outer cylinder walls and covers, and is admitted into the valve liner through ports *A* near the top. From the inside of the liner the steam passes into the cylinder through spiral ports *C* up to the point of cutoff, the clearance space shown above the piston being already filled with steam up to initial pressure, as before stated, and the cutoff being effected by the valve *D* driven by a slide rod.

After an early cutoff, the precise point of which is controlled directly by the governor, the steam expands during the remainder of the down stroke, and while the crank is turning the bottom center, the ports *E* in the center of the liner are opened by the valve *F*, called the transfer and exhaust valve. This valve *F* at the same time opens the ports *G* at the bottom of the cylinder, so that while the piston is making its up stroke a communication is made between the top and bottom of the cylinder, transferring steam at equal pressure and temperature from the top to the bottom of the piston. This transfer continues for about half the stroke. In other words, about one-half of the steam which was above the piston is transferred to the other side. The transfer is closed first by the piston overrunning the ports *E* in its upward stroke, and immediately afterward by the valve *F* closing the ports *E* and *G*. The steam

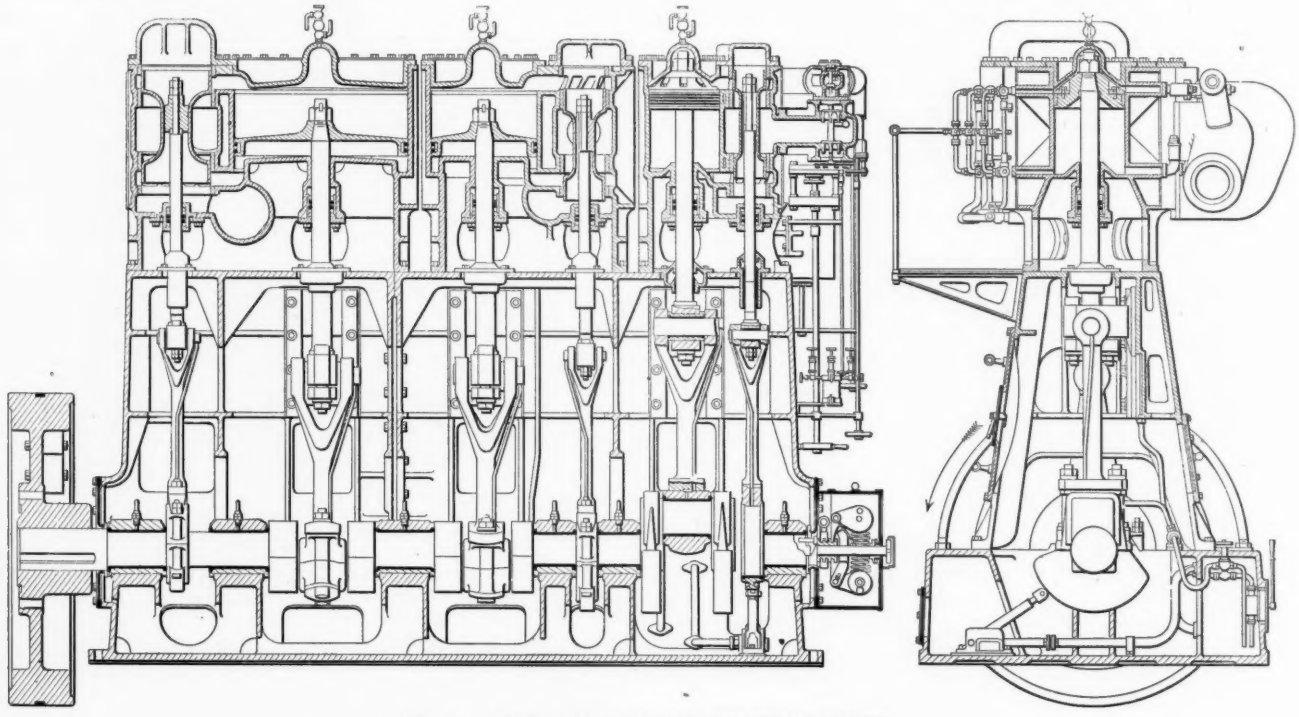


FIG. 21. W. H. ALLEN TRIPLE-EXPANSION ENGINE

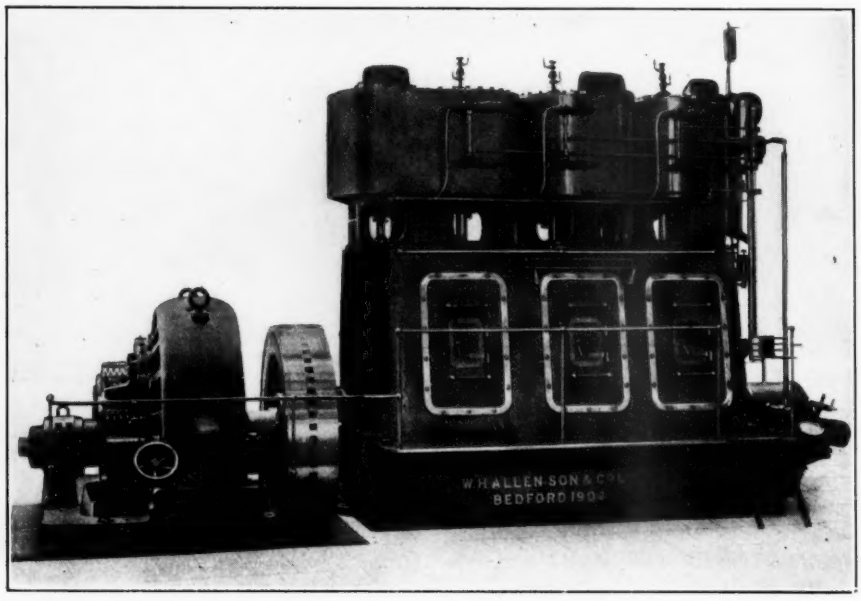


FIG. 22. EXTERIOR OF W. H. ALLEN TRIPLE-EXPANSION ENGINE

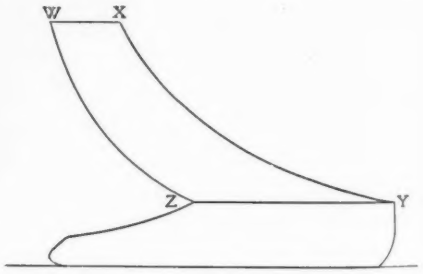


FIG. 24. TREORETICAL DIAGRAM FROM SINGLE-ACTING COMPOUND ENGINE

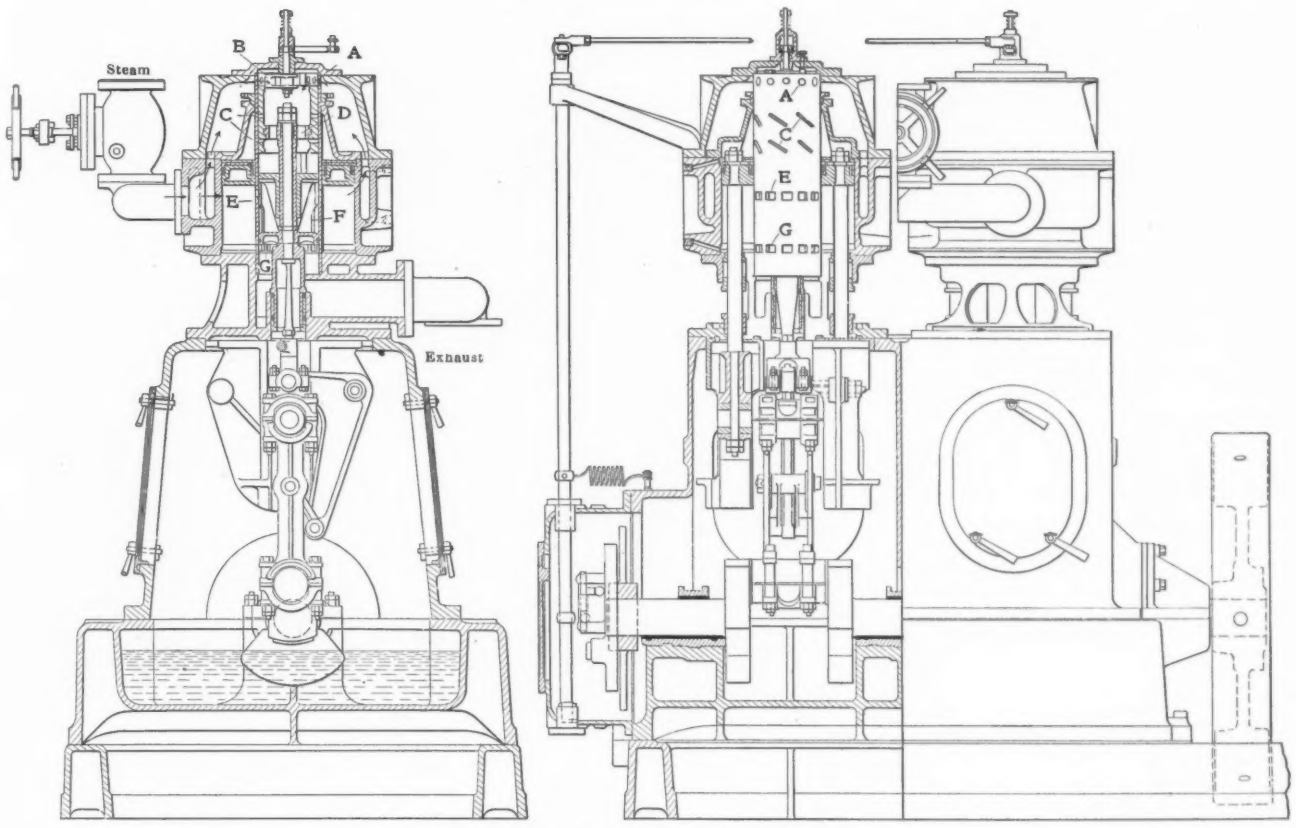


FIG. 23. REAVELL SINGLE-ACTING COMPOUND ENGINE

transferred to the under side then completes its second stage of expansion, and at the end of the upward stroke the exhaust valve opens and allows this steam to escape to the atmosphere or the condenser.

In the meantime, the steam which remained in the cylinder above the piston, when the transfer closed, is compressed during the latter half of the upward stroke, and the clearance space in the cylinder is so proportioned that this steam shall be compressed to initial pressure, when the termination of the stroke is reached, and the valve *D* opens for the next admission of steam. By this means the reciprocating parts are brought to rest, and the inertia is taken up by means of the working fluid itself, while at the same time the parts which will be first touched by the entering steam are already heated up to initial temperature and thus cylinder condensation is reduced.

Accurate and regular governing of the speed of the engine is obtained by a crankshaft governor which acts through the levers and governor bridge *B* and varies the point of cutoff of the admission valve *D*. This governor bridge has two guide studs fixed to it, which pass through holes

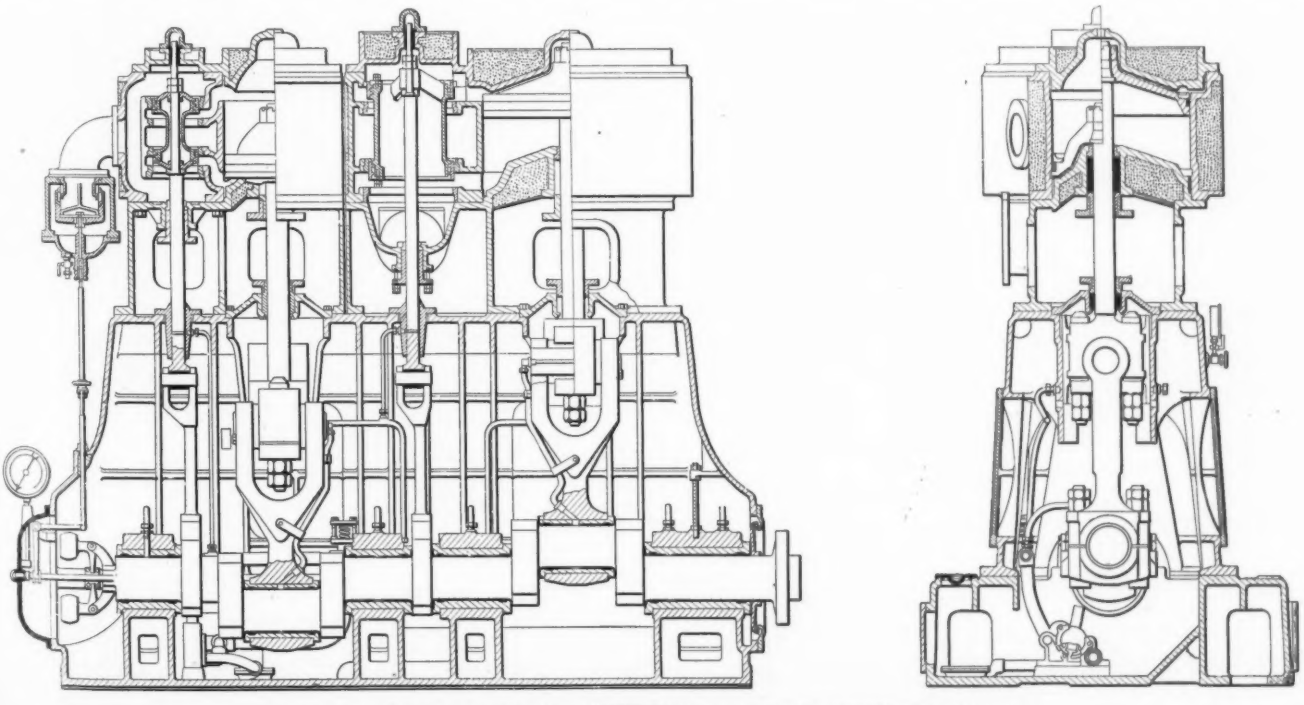


FIG. 25. STANDARD DESIGN OF BROTHERHOOD TWO-CRANK COMPOUND ENGINE

in the admission valve *D*. The valve *D*, though reciprocated by the slide rod and having a constant stroke, is free to be rotated by the guide studs on the bridge *B* and the ports in the admission valve are so arranged in connection with the ports in the valve liner itself that a slight axial movement will cause an alteration in the point of cutoff.

The valves are driven by a radial form of valve gear operating from a point on the connecting rod, and the positions of the valve-gear centers are so chosen as to enable a considerable variation in the point of cutoff to be obtained, with an exceedingly slight change in the amount of lead.

Lubrication is effected by the splash system. An oil and water bath is formed in the bottom of the crank chamber into which the bottom end of the connecting rod dips at every revolution, throwing a constant stream of oil over the working surfaces.

These engines are built only on the compound principle, but they are very economical, as will be seen from the results given in Tables 1 and 2. This is no doubt due to the small port clearances and the efficient jacketing made possible with this type of engine. Also cylinder condensation is greatly reduced by reason of the high compression which heats up the surface above the piston to the initial temperature of the steam before the valve opens to lead.

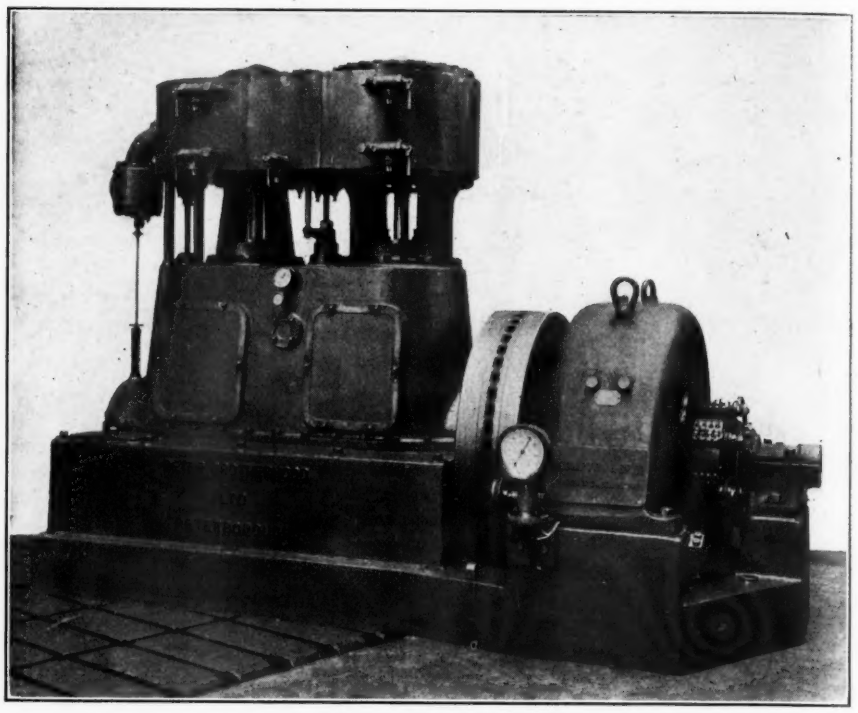


FIG. 26. BROTHERHOOD ENGINE COUPLED TO CROMPTON DYNAMO

Brotherhood. The firm of Peter Brotherhood, Ltd., whose productions are illustrated in Figs. 25 and 26, was really the first high-speed engine builder in this country. In 1883 the late Peter Brotherhood patented his three-cylinder engine. The cylinders in this engine were placed radially at equal distances round the crankshaft, and the three connecting rods were coupled to one crank pin. Further improvements were patented in 1885. A

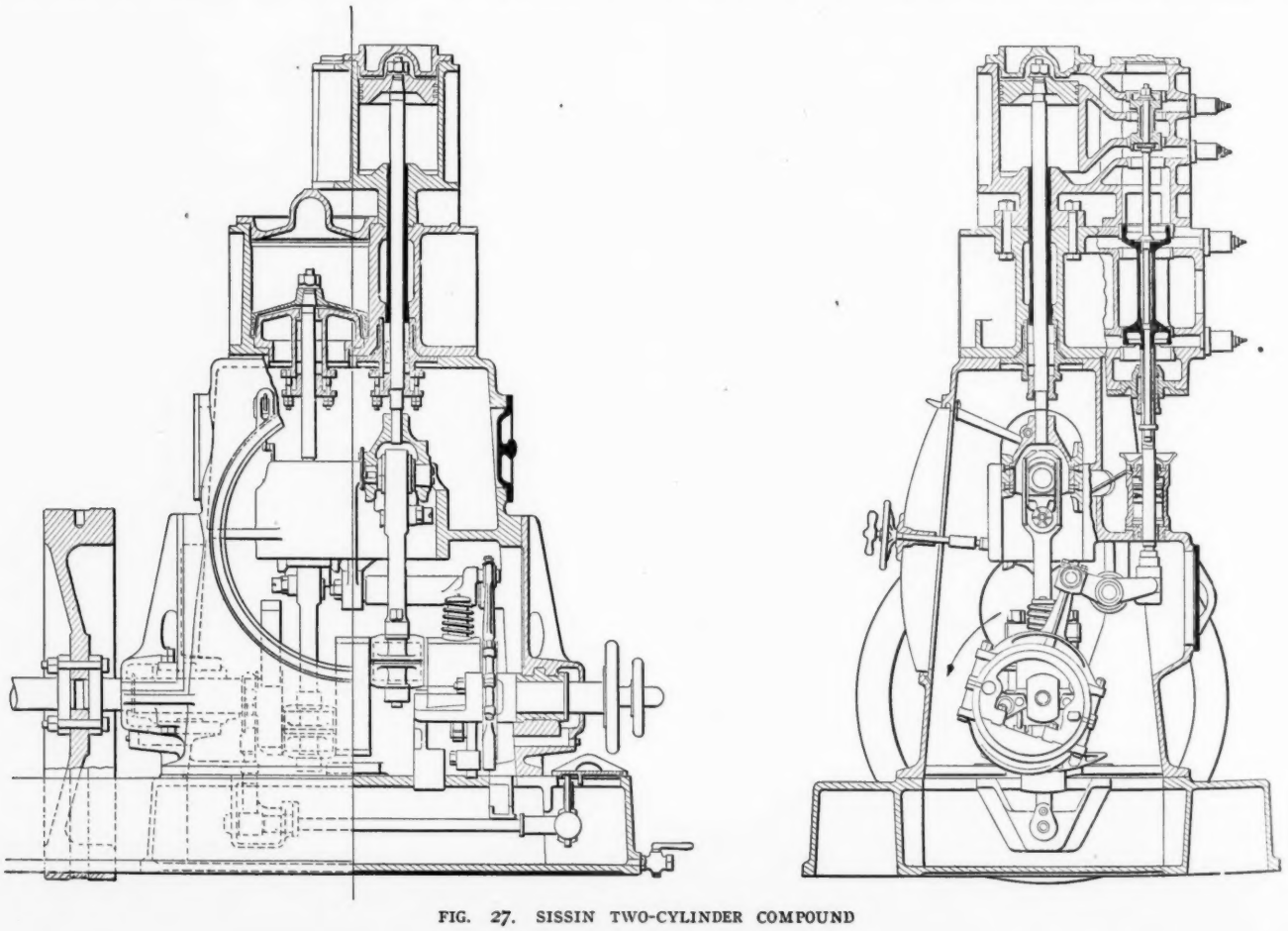


FIG. 27. SISSIN TWO-CYLINDER COMPOUND

large number of these engines were built and it will be remembered that it was only in the year 1885 that the late Mr. Willans patented his renowned central-valve engine, so Peter Brotherhood was the first to recognize in a practical way the need of a high-speed engine. This firm has manufactured a large number of inclosed forced-lubrication steam engines, and quite recently has put down a new works of much larger capacity at Peterborough. These works are fully equipped with modern machinery and are suitable for dealing with engines of the largest size.

The standard design of two-crank compound engine, as built by this firm, is illustrated in section in Fig. 25. It is built in sizes varying from 30 to 700 brake horsepower, and to run at speeds of from 550 in the case of the smallest size to 350 revolutions per minute in the largest sizes. The engines are stiffly built, and the bearing surfaces are of generous proportions. Separate piston valves are fitted to each cylinder, and the arrangement is clearly shown in the sectional elevation. This firm makes a practice of fitting eccentric straps of bronze, the rods being of forged steel. The pistons are made of forged steel, shaped to facilitate the drainage of water, and are carefully adjusted so as to obtain a perfect balance of the moving parts of the engine.

Special attention is also given to the lubricating arrangements. Two pumps of the valveless type are fitted, except in the case of the smallest engines, and arrangements are made so that either of the strainers may be removed while the engine is running. The other strainer supplying oil to the pumps meanwhile.

Accurate governing is obtained by means of a powerful centrifugal governor acting directly on the throttle valve. The following results of governing may be of interest. Engine No. 1538A was supplied to a Welsh coal mine, while No. 1573A is an engine installed in one of the British Government buildings:

	Engine No. 1538A.	Engine No. 1573A.
Steady speed at full load	450	505
Momentary maximum speed when full load was suddenly removed	458	510
Steady speed at no load	454	506
Momentary minimum speed when full load was applied	443	495
Steady speed at full load	450	505
Steady speed at ¾ load	450	505
Steady speed at ½ load	452	505
Steady speed at ¼ load	453	506
Steady speed at no load	454	506
Steady speed at 50 per cent. overload	450	505
Normal full load, kw	150	50
Steam pressure, lb. per sq. in	130	100

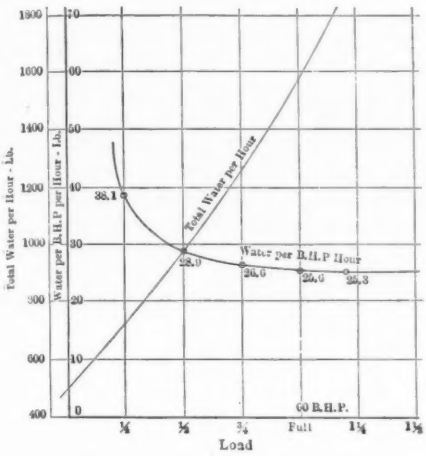


FIG. 28. WATER CONSUMPTION OF SISSIN ENGINE

TABLE 1. TEST OF 100-KILOWATT SET, CONDENSING.

	Steam Press. Lb. Per Sq.In.	Vac. Inches of Mercu'y	Speed R.P.M.	Amps.	Volts.	Kw.	I.H.P.	Steam. Per I.H.P. Hour.	Steam. Per Kw. Hour.	Combined Efficiency, Per Cent.
Over-load test	149	25½	444	248.6	506	125.8	203.7	15.90	25.75	82.6
Full-load test	150	25½	446	199	500.4	100.2	159.5	15.48	24.70	84
¾-load test	149	25½	448	149	505.5	75.3	125.0	15.60	25.94	80.75
½-load test	151	26	453	100	500	50	88.1	15.65	27.60	76

TABLE 2. TEST OF 150-KILOWATT SET, NONCONDENSING.

	Steam Press. Lb. Per Sq.In.	Vac. Inches.	Speed R.P.M.	Amps.	Volts.	Kw.	I.H.P.	Steam. Per I.H.P. Hour.	Steam. Per Kw. Hour.	Combined Efficiency, Per Cent.
Over-load test	151	.....	338	362	499	180	289	19.75	31.75	83.7
Full-load test	150	.....	346	300	500	150	245.8	19.12	31.30	82.0
¾-load test	148	.....	348	225	498	112.2	197.6	19.00	33.35	75.25
½-load test	149	.....	350	155.5	499	77.6	145.8	19.55	36.75	71.3

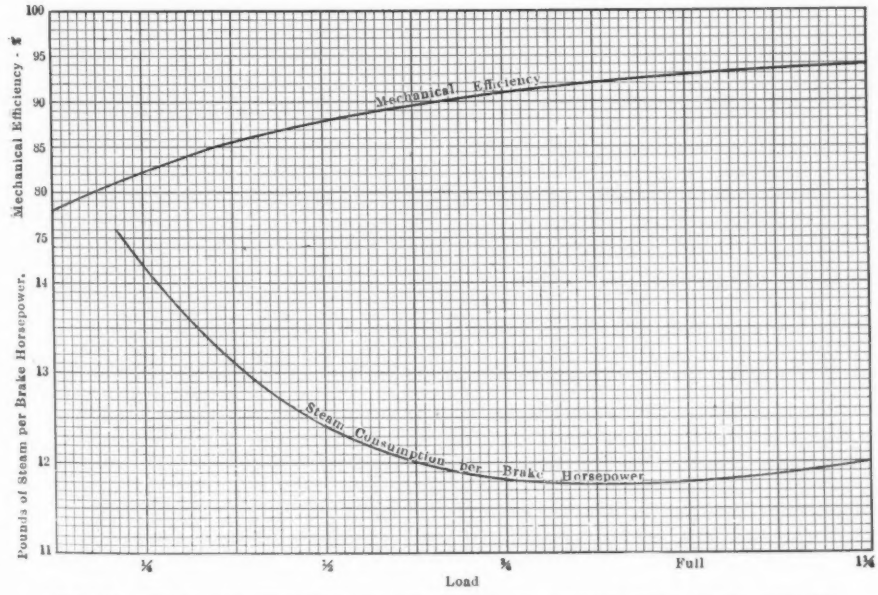


FIG. 29. STEAM CONSUMPTION AND EFFICIENCY OF BRITISH HIGH-SPEED ENGINES

No hunting or irregular working under any condition of load, speed or steam pressure.

The exterior appearance of the engine is shown in Fig. 26, which is a photograph of a Brotherhood engine coupled to a Crompton 200-kilowatt dynamo.

Sissin. An engine possessing both novel and efficient points in design is that manufactured by W. Sissin & Co., Limited, of Gloucester. The engines are made in two types: single-cylinder and two-cylinder compound. The compound engine is illustrated in section in Fig. 27. The high-pressure cylinder is partly superposed, and by this arrangement the cranks are brought so close together that there is only sufficient room for a substantial web between them. The cranks are opposite, and owing to the short distance between their centers, they balance one another almost perfectly. The engine is specially suited for superheated steam, since the high-pressure piston rod passes down through a long gun-metal-lined trunk, so that the steam-heated portion of the rod does not come into the packing space at all.

The engine is simple. It has only two main bearings, and the arrangement of valves, in all except the largest sizes, is such that there is only one valve-spindle stuffing box, and that is only subject to receiver steam. Both valves are actuated through a rocking lever from a powerful crank-shaft governor. The valve chests

are fitted with separate liners of special nickel-iron alloy.

The framing is of ample strength. The lower part forms an oil trough and is fitted with an inspection door and drawoff cork. Large openings are arranged in the ends of the frame above the shaft, which are closed by flanges attached to the main bearing caps, and when these are removed the crank shaft can be readily withdrawn through the opening at either end, for the flywheel can be disconnected from the shaft and again fixed without any difficulty, as it is spigoted onto a solid-flange coupling.

The speed of the engine is controlled by altering the cutoff, although at light loads the governor has a throttling action on the steam. These engines are economical for their size, as will be noted from the two curves given in Fig. 28, which were plotted from data on a 10½x6-inch engine. Initial pressure 150 pounds and atmospheric exhaust.

To illustrate the best results obtainable as regards steam consumption and efficiency with British high-speed engines, when working under ordinary conditions, the curves in Fig. 29 are given, which clearly show the steam consumption and efficiency of a modern triple-expansion engine at all loads from no load up to 25 per cent. overload, when working with steam at a pressure of 175 pounds per square inch, superheated 100 degrees Fahrenheit and exhausting into a condenser with a vacuum of 26 inches.

American Society of Hungarian Engineers and Architects

A number of Hungarian engineers and architects pursuing their professions in this country have organized the American Society of Hungarian Engineers and Architects. The society has two objects: First, to bring in closer touch engineers and architects of Hungarian extraction, living in this country, and to give moral support and information to newcomers; second, to encourage the exchange of engineering, technical and industrial information between the technical men of Hungary and of the United States and to foster technical societies, sciences and industries.

The society will hold monthly meetings where papers will be read and discussed. The membership consists of mechanical, electrical and civil engineers, chemists, architects and craftsmen. Following are the officers of the new society: President, A. Henry Pikler, M. E., member of the American Institute of Electrical Engineers, engineer-in-charge of the transformer department, Crocker-Wheeler Company, Ampere, N. J.; vice-president, Karoly Z. Horvay, architect, chief draftsman, building bureau of the Board of Education, Brooklyn, N. Y.; secretary, Zoltan de Nemeth, M. E., New York Edison Company; treasurer, Sandor Oestereicher, E. E., associate member of the American Institute of Electrical Engineers and of the American Society of Mechanical Engineers, New York Edison Company; assistant secretary, Ernest L. Mandel, B. S. C. E., Bureau of Commissioner of Public Works, New York City. The society's business address is P. O. box No. 1031, New York City.

Graphite as a Lubricant for Gas Engine Cylinders

By Walter N. Durant

Becoming interested in the above subject and having access to a new 6-horsepower horizontal engine, using city gas for fuel, I determined to make some experiments. Finding it impossible to mix graphite and oil and feed it through the ordinary lubricator, the experiments were confined to feeding the graphite dry through the air intake and continuing the use of cylinder oil through the lubricator. At first about an ounce of graphite was fed through the air intake at short intervals, but after each charge the engine would show increased internal friction; however, it would quickly pick up and then appear to run smoother than before. The quantity of graphite was reduced and it was soon found that the best results were obtained when the engine was not given more graphite than could be consumed in the cylinder, or about 1/12 to ⅛ ounce per horsepower in a 10-hour run. This amount should not be fed all at once, but distributed as evenly as possible throughout the 10 hours.

The experimenting extended over a period of four months, and during that time the engine was given some severe tests. The spark plug was always in good condition and never missed fire, or became carbonized or short-circuited. The cylinder and valves were frequently examined; the latter were in fine condition and the cylinder did not show a sign of a scratch, but had that smooth, dull appearance which indicates the absence of friction. Unfortunately it was impossible to determine the amount of fuel saved by the use of graphite, as the engine was under a constantly varying load.

Desiring to know what others thought of graphite as a cylinder lubricant, I wrote to 45 prominent gas-engine manufacturers, asking if they recommended its use in their engine cylinders. The majority of replies stated that the writers had none, or very little personal experience, and declined to express an opinion. The answers containing advice were interesting, but rather conflicting, and no information could be gained from a reply like this:

"It is not customary with us to use graphite in the engine cylinders, although we sometimes use a little."

The following is a little more explicit:

"The great trouble with graphite is to apply it properly, so as not to plug the rings and make them stick. If properly applied, however, graphite is indeed an ideal method of lubrication, but, of course, must be used with oil."

A prominent firm making high-grade auto engines writes:

"We would recommend the use of graphite once in a while in your crank case. Same will do no harm. It has a tendency to close the pores of your cylinder and polish same up so as to increase the compression. It is a good thing."

A large marine gasolene motor manufacturer also says:

"Smear the cylinder walls with it. Once a month is often enough to do this. Of course, in addition the regular amount of oil should be fed through the multiple oiler. Graphite will help to retain good compression."

Another well known gas-engine company writes:

"We use more or less graphite in connection with lubrication, and where properly used much better results can be secured than with lubricating oil alone. If the cylinder has been allowed to cut slightly because of lack of oil there is nothing that will put it in shape so quickly as the use of graphite. Where good flake graphite can be mixed with oil and fed to the cylinder good lubrication is certain."

The manager of a large company making gasolene marine engines writes:

"We consider graphite the best lubricant in the world for gas-engine cylinders. The trouble in using it is in getting it into the cylinder. So far no satisfactory means have been devised. We think so much of the lubricating qualities of graphite in cylinders that we make it a rule thoroughly to coat the inside of every cylinder with it before sending our engines out from the factory. If one of our customers should ask us the question we would tell him to use it by all means if he could get it into the cylinder."

A New York City builder says:

"We think graphite lubrication is very good provided you have the proper means for furnishing the graphite in the required and constant quantity so that it will reach the parts to be lubricated."

The objections to its use were: "Forms lumpy spots on valve seats. Has a tendency to carbonize spark plugs. The expense in using it would overcome the advantages."

Nearly all of the firms which did not recommend the use of graphite, pointed out the impossibility of mixing graphite and oil and the certainty of clogging the lubricator if fed in that way. Aside from this, the only objection I can see is in using too much at one time in small cylinders.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

A Boiler as a Water Supply Tank

The mistakes and absurdities that inevitably blaze the path of the inexperienced technical graduate who launches out on his own hook in an advisory or supervisory capacity are exemplified in the device described herein in connection with the water supply in a hotel building.

The house pumps in this hotel are two electrically driven centrifugals, one of which is always held in reserve. The boiler plant consists of two 72-inch by 18-foot horizontal return-tubular boilers, cross-connected by a steam drum as shown in Fig. 1, and used alternately. The genius who performs the function of consulting engineer to the owners of the property in question, thought it would be a capital idea to utilize these boilers as pressure tanks on the house water-supply system, during their periods of temporary inactivity as steam generators, instead of placing a tank for this purpose in the attic.

Accordingly, acting on the inspiration, he had a discarded 8-inch Westinghouse air pump, of the locomotive type, rigged up as shown at *A*, with the discharge pipe coupled to the water-column connection to the steam space in each boiler; further intending to connect the blowoff pipes from the boilers to the house water system, as shown in Fig. 2.

The purpose contemplated in the installation of this contrivance was to pump an 80-pound air pressure on the water in the boiler out of steam service, and then to cut the boiler in on the water system and permit the expansive force of the air to send the water through the pipes until the pressure would drop to 60 pounds, the house pump being cut out in the meantime by an automatic switch in the motor circuit set to open at 80 pounds, and which would again operate to close the motor circuit at 60 pounds, and thus put the pump in motion again until the 80-pound air pressure was reëstablished, when the same cycle of events would be repeated. The ultimate object of the whole thing was to economize on the power expended in driving the centrifugal pump, this power being supplied from an outside source.

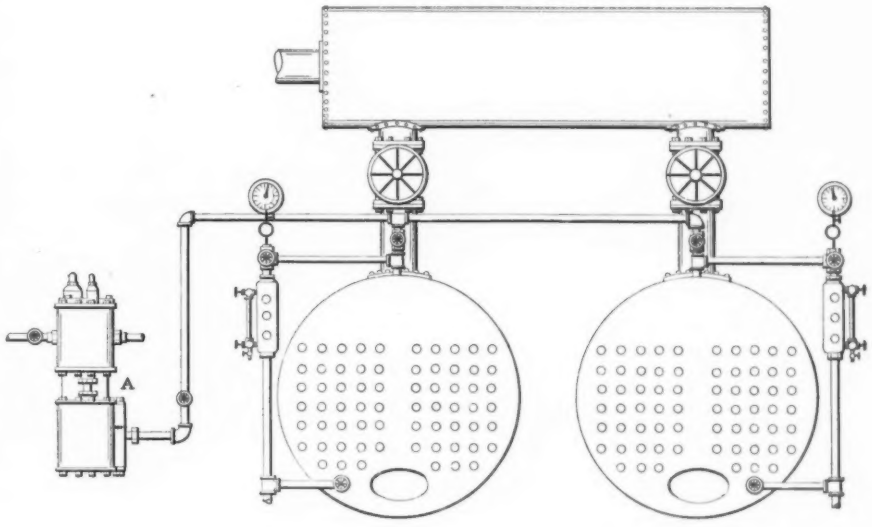


FIG. 1. SHOWING AIR-PUMP CONNECTIONS

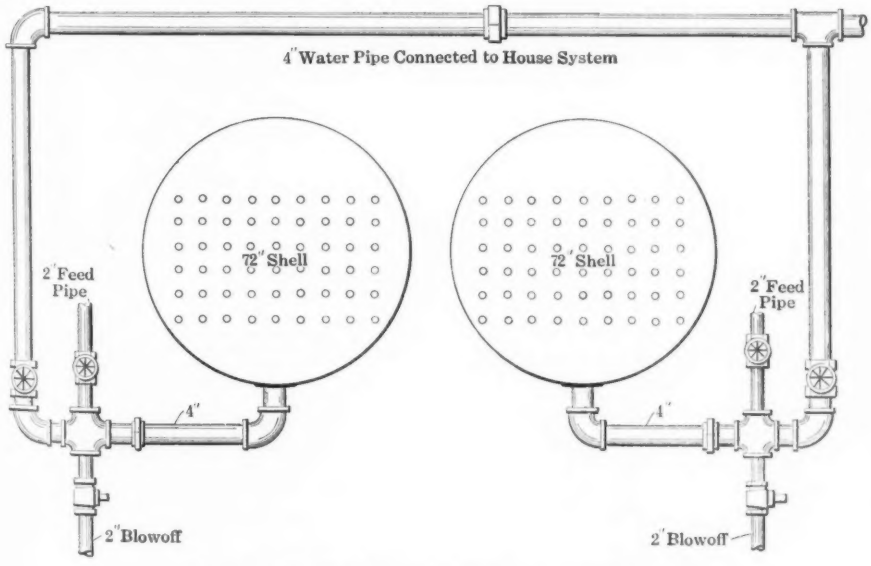


FIG. 2. SHOWING PROPOSED BLOWOFF CONNECTIONS

The job was begun some months ago, but at the time of this writing it has progressed no farther than the air connections to the water-column pipes. Whether the deviser of the apparatus got a tip from the boiler inspector, or was called off from some other source, or dropped it of his own accord, or is only holding it in abeyance, to be completed later on, is not known.

Leaving out of consideration the facts that the safety valves on these boilers are set at 80 pounds and that the air pump is a played-out piece of apparatus of rather ancient type, and would probably be doing extremely well to give a mechanical efficiency of 80 per cent., it would be quite interesting to know what practical men think of the project on general principles.

A. J. Dixon.

Chicago, Ill.

Babbitting a Pinion

Some time ago a loose pinion, 18 inches long, required babbitting. As I was unable to babbitt it on the shaft, it was removed and a wooden roller dressed down, supposedly the same diameter as the shaft. When I tried to replace the pinion on the shaft, I found that I had dressed the roller down too much, making the babbitted hole too small for the shaft.

I had another old shaft of the same diameter with a long keyseat at one end, the edge of which was a trifle higher than the rest of the shaft. The end of the old shaft was put in the babbitted hole of the pinion, and taking a half hitch with a chain around the shaft, with the aid of two men to turn the shaft, the weight caused the shaft to work down through the babbitt as it revolved, the high side of the keyway acting as a cutting tool, making a nice fit in the pinion to the shaft.

P. C. Forgard.

St. Paul, Minn.

Friction Clutch Trouble Remedied

For the benefit of those who are having trouble with friction clutches, I will cite an experience that ended my clutch troubles. One clutch in particular gave considerable trouble. Four arms holding the shoes broke one evening, and were replaced. After a few weeks one of the arms on the spider cracked, necessitating a new spider. In a few weeks more another arm on the spider broke. We replaced the old spider with the new, and proceeded to line it up. After lining up we threw the clutch in and tightened the shoes. That was as far as I had ever seen any lining done by anyone, and leaving off at this point was where we had been making our error. After tightening the shoes the clutch was released and thrown in again, and as I was watching it closely I saw the spider move a little to one side. This was where the trouble was. In tightening the shoes we had not got an even strain on all of them and on closing the clutch the tightest shoe would crowd everything out of line, there being a small amount of lost motion in the journal. We equalized the strain on all the shoes until we could throw the clutch in at any position and have it remain true.

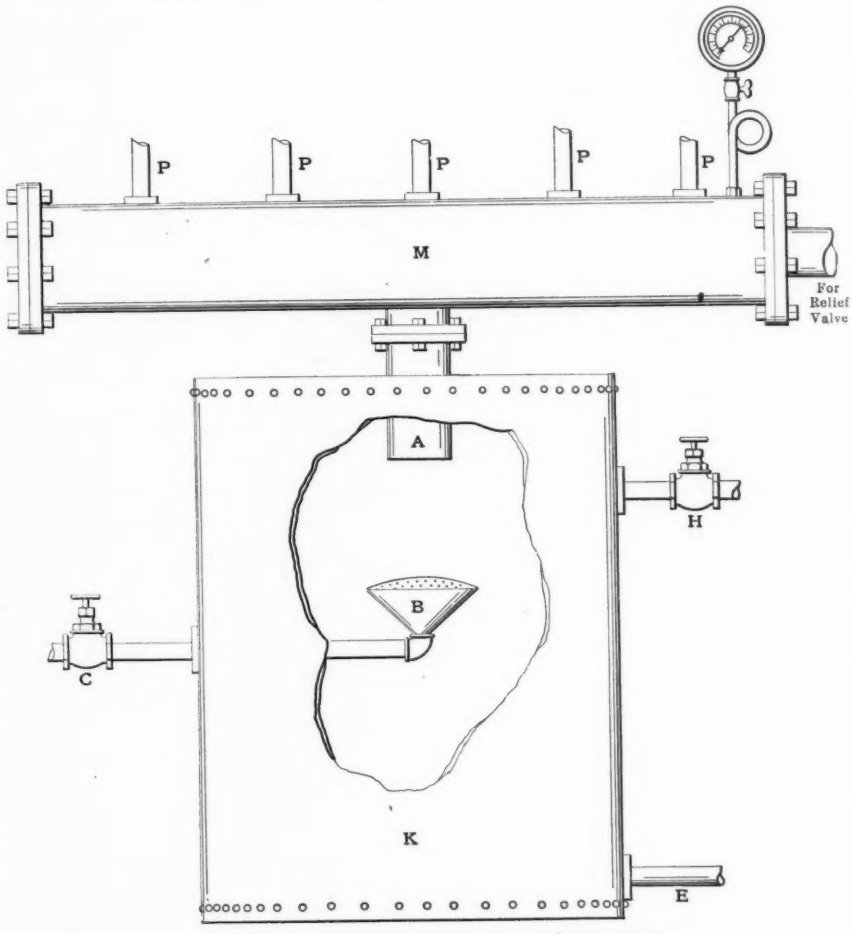
In lining clutches on quills, the opposite end of the quill should be carefully lined. If one side is pushed out it shows that the opposite shoe is too tight. Either release it, or tighten the side that is out. A good fit is all that is necessary to do the work.

Remoh Lenoie.

Keene, N. H.

A Homemade Condenser

In the December 29 number M. D. Casper asks for a description of a homemade condenser for exhaust-steam heating. There are steam plants run on the vacuum system giving perfect satisfaction, where no condenser is used; simply a receiver tank which collects the air and water in the system; these in turn are pumped out by a vacuum pump which maintains a constant vacuum of any desired degree in the returns. In the sketch *K* is a square or cylindrical vessel, *M* is the receiver main and *P P*, etc., are the returns. The receiver main is connected to *K* by the pipe *A*. Valve *C* is for the injection water. At *B* is a perforated rose which scatters the water over the entering steam. At *H* is an auxiliary water pipe connected to a pump or city main. It is to be used should the condenser get too hot through shortage of injection water, etc. The pipe *E* is to be connected to the air pump; a check valve is shown on the end of it.



HOMEMADE CONDENSER SUGGESTED BY MR. NOBLE

The form of a common jet condenser is immaterial, but care should be taken that the mains cannot be flooded to such extent that the water will reach the engine. A suitable relief valve attached to the condenser tank would be advisable.

J. S. Noble.

Toronto, Can.

Kerosene in Steam Boilers

I have noticed for years first one letter and then another dealing with the use of kerosene for removing scale in steam boilers, also the devices for feeding it. While the arrangements for using kerosene show much thought and no small amount of ingenuity, the same amount of thought on the natural philosophy of the thing would convince anyone that using kerosene in a steam boiler with steam over 212 degrees Fahrenheit is time wasted.

I have tried kerosene in boilers under pressure and used it in boilers with no pressure, and the only time I have found it of any use as a scale remover is when a boiler may stand idle and empty and the kerosene put in, then slowly feed water to the boiler until full. Then, after about one hour, let the water out, so as to allow the oil to cover the tubes, heads and shell and allow the boiler to stand as long as possible. A good dose of rainwater in a steam boiler is the best scale remover I have found yet.

Regarding kerosene in boilers under steam pressure, I have noticed that a long time before I could hook the boiler to the others, the engine and boiler room were full of kerosene fumes. As I only have about 20 pounds steam pressure, how

much kerosene will be left when I connect it to the other boilers?

The boiling point of fresh water is 212 degrees Fahrenheit, at sea level. I have often noticed on a barrel of the best illuminating oil the figures 150 degrees, and have assumed this was the point it would vaporize at. Now there is some difference between 150 degrees and the temperature of steam at 100 pounds pressure, and I have come to the conclusion that the kerosene in a boiler has passed off in the form of vapor long before any steam is used from it.

I am afraid a good many engineers are under the impression that kerosene can be pumped in a boiler under steam pressure and help remove scale, but it will not do the work.

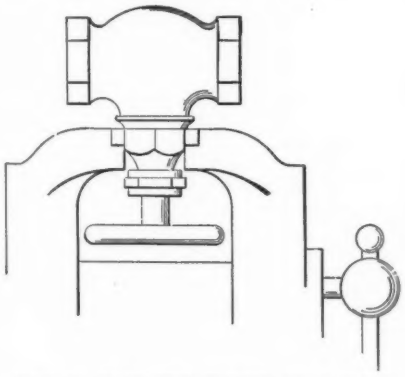
JAMES C. MELLEN.

Brooklyn, N. Y.

Globe Valves

Many practical hints were given in Mr. Wakeman's article on globe valves, published in the January 5 number. In regard to valve disks, the flat spots referred to certainly form an effective locking device, as in nine cases out of ten it is useless to try to remove the nut with a monkey wrench after the disk has been in use some time. If the disk is first split in two or three places, and a piece taken out, the rest will generally turn easily enough without doing any damage to the nut.

This operation is more simple than filing down the flat sides, as recommended



HOW TO TAKE THE BONNET OF A GLOBE VALVE OFF

by Mr. Wakeman, and as the nut is apt to work loose, due to vibration in the steam pipes, I think the locking arrangement preferable.

It is a good idea to take off the bonnet of a valve before it is put to use, but these bonnets are often screwed up so tightly before leaving the shop that a monkey wrench will not loosen them without slipping and rounding the corners.

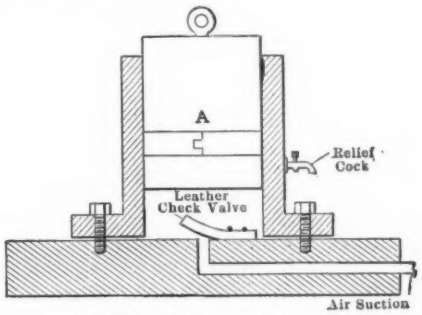
The safest way under any circumstances is to put the valve in a vise, as shown in the sketch herewith, with a piece of tin bent over the jaws to prevent marring the hexagon surface. Then screw a piece of pipe in one of the openings, or in both if the bonnet is very tight, and it is bound to come loose with the least possible chance of springing or twisting the body of the valve out of shape.

R. CEDERBLOM.

Gary, Ind.

Badly Worn Dashpots

A short time ago a young engineer was called upon to set up a large engine. The engine in question was an old-fashioned



REPAIRING A BADLY WORN DASHPOT

Corliss, and the worn dashpots gave considerable trouble. As he could not induce the firm to put in new ones, he had to devise some method of repair.

The dashpots were of the old-fashioned type, with a solid plunger, the valves being closed by a dead weight. The dashpot plunger, when new, was turned up to an easy fit in the dashpot, at the bottom of which was a leather check valve to control the air. The dashpot stood on a cast-iron base plate having a hole drilled in it from the side and connecting with a vertical hole in the center of the dashpot underneath the leather check valve. When the plunger of the dashpot was raised it created a vacuum, causing the leather check valve to be raised, thereby admitting air to the dashpots. When the valve was released and the plunger fell, thus closing the valve, this leather check valve closed, retaining a portion of the air in the dashpot and creating a cushion which prevented the plunger from striking the bottom. At the side of the dashpot was a cock to regulate the amount of air, as required. These plungers were so badly worn that the air leaked out, allowing them to pound on the bottom of the dashpot each time they seated. The regulating cocks were of no use whatever, as they were entirely closed.

As there was a small lathe on the premises, run by another engine, the engineer took out the plungers and turned a groove in them at the center, these to take just two pump packing rings with a good working fit, as at *A*. The rings were peened so that they were a trifle larger than the inside of the dashpot, thus causing them to be slightly pressed together when in place. When the engineer got the dashpots adjusted again he found that they worked nicely and he has had no further trouble.

FRANK L. FERGUSON.

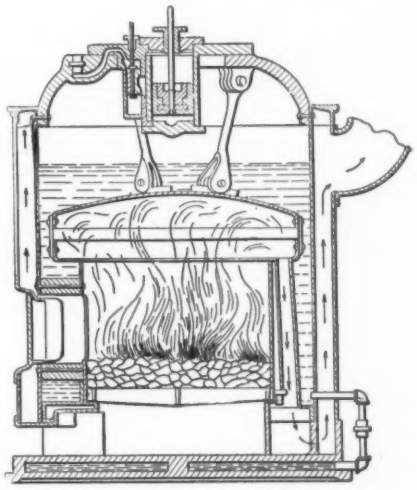
Adams, Mass.

Down Draft Furnaces

The first "down-draft" furnace was patented in England in 1830 by Lord Dukdonald, a draftsman who amused himself with engine and boiler experiments. The patent expired in 1844; in 1846 they began to be made in New York City and other places and were approved by leading engineers, for two reasons: First, the hottest fire was under the thinnest and most solid body of water in the boiler; second, the priming, foaming and squirting due to the up-draft furnace were not nearly as bad with the down-draft furnace.

The plans were different from ours, as the fire was under the boiler at one end and the coolest gases under the other end, whereby if there were any unequal expansion, it developed about the space of the wall dividing the two horizontal planes and gas chambers, and the solids in the water were found over that wall at the bottom of the boiler.

In the boilers we built the furnace was inside the front of the boiler, and there was a vertical plate at the rear from which



AN OLD TYPE OF DOWN-DRAFT BOILER

the top flues started above the fire, ending in a back connection surrounded with water inside the boiler shell. Another row of flues or tubes passed below the first row, from the back connection to a front one; another row below the second one joined the front cover to a box in the rear, out of the upper side of which projected the smokepipe. These three connections were boxed by 4 or more inches of water in the boiler, so that wherever there was heating surface the water got some benefit.

In the Kirlin boiler, the rear gases enveloped the whole end of the boiler, but

did no good, because heat will not move downward, unless it is forced, and there was not heat enough at that point to raise any perceptible heat above that due to the steam already there.

There was another boiler with down draft, built for a Mr. Baxter, a sketch of which is shown herewith. It is the true Dukdonald boiler, but the engine in the top was the invention and patent of William Murdock, a Scotchman, in the year 1770. So it may be seen that Solomon was not such a fool when he said: "The thing that hath been is the thing that shall be;" and "there is no new thing under the sun." Though I quote him, I demur thereto; for if there had not been an original somewhere, there could not be copiers.

PETER VAN BROCK.

Jefferson, Ia.

A Remodeled Steam Plant

During the fall of 1907, when the writer came on the scene, the plant belonging to the Hoopeston Gas and Electric Company consisted of a 150-horsepower Stirling boiler, two 100-horsepower tubular boilers, one 14x14-inch Ideal and one 11x24-inch Corliss engines, three 1100-volt single-phase 125-cycle alternators and two 500-volt direct-current generators. The electrical machines were belted to the engines in such a way that one engine could carry the day load, which was comparatively light, and the other the heavy evening load until midnight. The day load consisted of a few 500-volt motors scattered around and a number of flatirons. The night peak load was occasionally as high as 80 kilowatts, and the street lighting consisted of five arcs and 128 thirty-two-candlepower incandescent lamps on a midnight moonlight schedule.

The equipment was of ample capacity for the existing load, but any considerable increase could not be handled without further additions to both prime movers and the present single-phase system, or a complete remodeling. Steam leaks were manifold and multiform. Secondary wires were of small cross-section and of great length. All lines were in bad shape, and it was no uncommon occurrence, on wet, windy nights, for the circuit-breaker to show signs of great activity.

With the advent of a new enterprise an aggressive power campaign was decided upon, and a 85-kilowatt generator was purchased and belted to the Corliss engine. Shortly after, the question arose as to new prime movers and a twin cylinder, single-acting, 280-horsepower gas engine was decided upon. Anthracite suction-gas producers were also purchased, and a 200-kilowatt generator was bought and belt-connected to the engine. Preparations for the immediate installation of the new equipment were at once made and the existing apparatus was crowded to the rear of the building. Part of the front wall was removed, one stack taken down and two tubular boilers skidded to the exterior so that foundations for the producer equipment could be constructed.

For a period of some seven months the Corliss engine struggled along under the heavy load imposed upon it, occasionally developing as high as 120 horsepower. The main-bearing pillow block was reënforced and a support placed under the guides, hoping to delay the inevitable, which finally came at 4 a.m. one morning, in the shape of a broken pillow block and cap, which allowed the shaft to drop down and forward, twisting the valve rods, breaking one steam arm and throwing one exhaust valve under. No one knew how it happened, but it was generally ascribed to old age and heavy overloads. The generator was shifted over to the piston-valve engine and for two months this engine ran continuously with only an occasional stop for packing purposes.

The old wooden switchboard was dismantled and a new five-panel marble board installed, carrying oil switches and like apparatus in keeping with the rest of the equipment. A 30-horsepower 2000-volt motor was purchased and direct-coupled to one of the old 500-volt machines, which had hitherto been belt-driven. Owing to the fact that this machine was only of 56 kilowatt capacity and that it had 150 horsepower in small motors already on its mains, no more direct-current power was solicited, but three-phase 440-volt power was pushed and at the end of six months 85 horsepower in this type of motors were connected and at the end of another six months 135 horsepower.

An uptown office was established and the supplies were taken care of from this point. Our only competitor, who ran a plumbing shop in connection with the electric-supply business, was bought out and the light company thereafter did all wiring and furnished all supplies. An advertisement was run in each of the local daily papers and changed weekly.

Owing to the fact that the primary voltage was doubled and inasmuch as the lines were sadly in need of repair, considerable time was spent placing these in first-class shape, some 20 transformers were thrown out and all meters were readjusted for the new frequency. A number of fan motors were changed and a

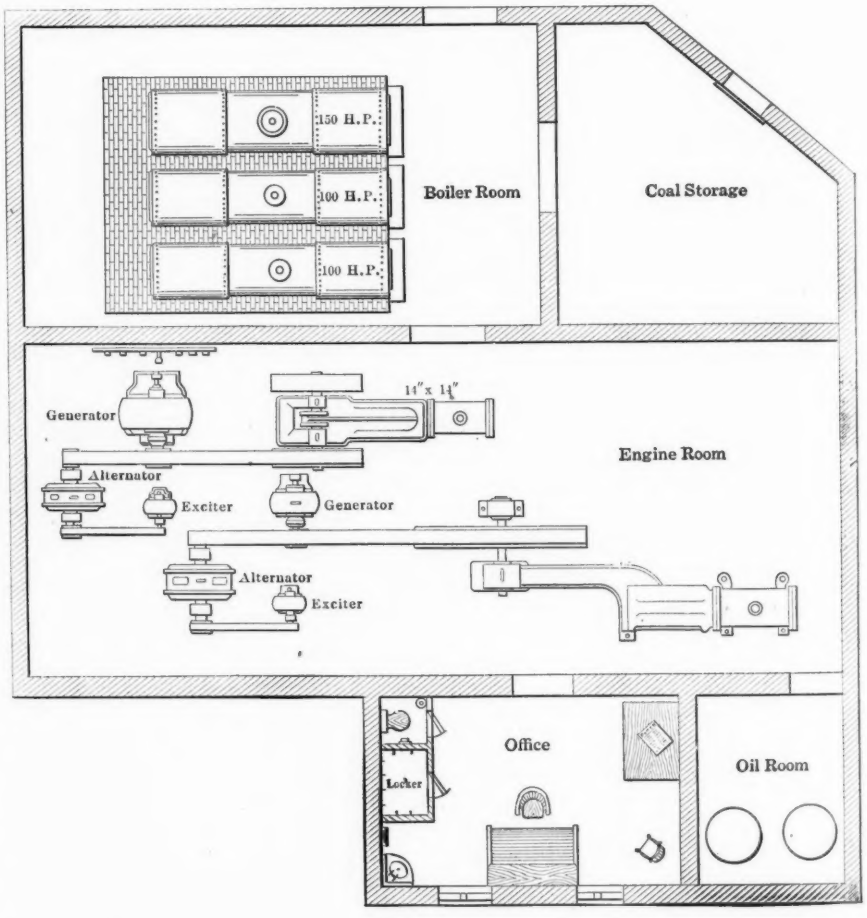


FIG. I. THE OLD LAYOUT

few small single-phase motors were got rid of.

As is shown in Fig. 2, one boiler, engine and generator were left in complete repair so that this apparatus could be started up at once should the gas equipment be disabled. It has been found necessary to resort to this arrangement two or three times for a day or so at a time in order that minor adjustments might be made on the gas engine.

Seeing the need of means of hoisting the coal to the tops of the producers, a motor-driven chain hoist was added to the station equipment, and a power head driven by a 5-horsepower motor for the deep-well pump was put in. This latter proved a great saving, as the consumption of city water for the gas engine for cooling purposes and for the wet scrubber in the producer room was no inconsiderable item. All wires were taken from the ceiling and placed in conduits under the floor and the ceiling taken down. This additional head room afforded better light and ventilation and presented a more pleasing appearance.

In due time the new equipment arrived and was placed in position. For the first few months we were troubled somewhat by the slowing down and speeding up of the engine, owing to governor troubles and improper mixtures. All this was corrected as soon as we secured a practical gas man to take charge of the equipment. The engine is called upon to deliver about 125 horsepower during the day and upward of 250 horsepower at night until 11 p.m., when the load drops to 25 horsepower.

A marked difference was at once apparent in the coal consumption, notwithstanding the unfavorable conditions the plant operates under, running for one-third of the time at practically one-tenth load. The company is now figuring with the engine builders for a second engine of the same type, but of smaller size, and when this is installed and running during the lighter load periods, 1¼ pounds of coal per horsepower-hour will doubtless be realized.

The dotted lines in Fig. 2 show the probable location of the next engine to which will be belted the 85-kilowatt generator. When this change is made the steam engine and remaining boiler will be removed, which will make room for one more producer of the same capacity as those now installed.

C. E. Bryson.

Hoopeston, Ill.

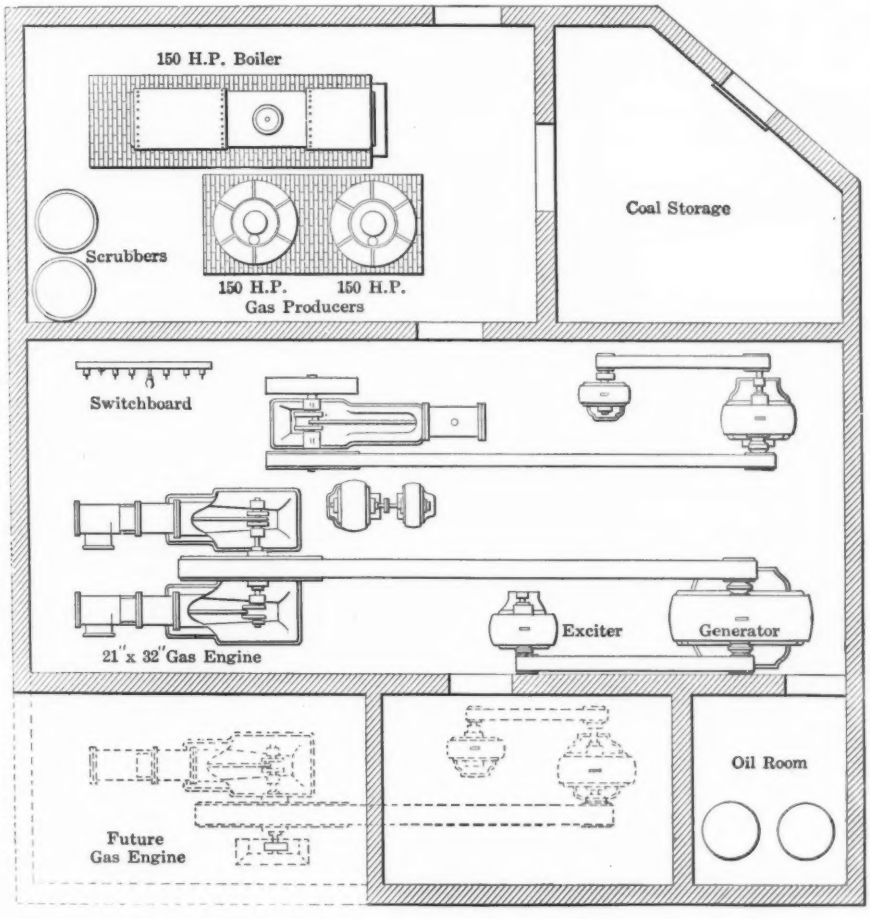


FIG. 2. THE NEW ARRANGEMENT

Drum Motion Distortion

In the article on drum-motion distortion, published in the issue of January 26, I see that I made several statements which may lead to erroneous conclusions, and therefore think it well to give the following as additional to that article:

As has been previously pointed out, this cause of distortion in indicator diagrams may be analyzed by considering the variation in the force existing in the cord during a cycle of the drum motion. This force is the resultant of the spring tension and the force of acceleration of the drum, which act in the same line. Beginning at the head-end dead center, the spring tension is minimum, while the force of acceleration is negatively maximum (under the assumption of harmonic motion); that is, the drum acts as a drag. Thus, the force in the string is the numerical *sum* of these two forces. At the crank-end dead center, however, the force of acceleration is positively maximum; that is, the inertia of the drum here helps it onward; and therefore the active force in the cord is the numerical *difference* between the accelerating force and the spring tension at the crank-end dead center. If these forces in the cord are equal at the ends of the stroke (as they may be), and if the force of acceleration increases in the same way as the spring tension, there would be no deformation in the diagram. The latter condition, however, cannot ordinarily be fulfilled, as the spring tension increases uniformly throughout the stroke of the drum, while the force of acceleration increases according to another law, except under the condition of harmonic motion which is only approximately satisfied.

The following numerical example may make clear an interesting characteristic of drum-motion forces: Suppose the speed of the drum is such as to give an initial accelerating force of -1 pound and, at the end of the stroke, a force of $+1$ pound. If the corresponding spring tensions are $+2$ pounds and $+4$ pounds, the forces in the cord will be $2 + 1 = 3$ pounds and $4 - 1 = 3$ pounds; and, therefore (for harmonic motion), constant throughout the stroke. Now, if the speed is increased so that the accelerating forces are -2 and $+2$ pounds, we cannot again obtain a constant cord tension by varying that of the spring, because the range through which the two forces operate are equal only in the case cited. For instance, if the spring is tightened so that the initial tension is 3 pounds, the final would be 4 pounds (the increase always being constant for the same extension of spring). The forces at the ends of the stroke would then be $3 + 2 = 5$ pounds and $4 - 2 = 2$ pounds. The conclusion is reached, therefore, that for any drum spring of given strength there is only one speed at which there is approximately no

distortion of a diagram of a given length. At other speeds the best tension is obtained as previously described.

J. C. SMALLWOOD.

Philadelphia, Penn.

Verifying Motor Connections by a Diagram

I had just finished reading the "Catechism of Electricity" in the January 5 number, when the chief came in and asked me to reverse the rotation of a motor. We have about twenty motors and they are apparently all shunt-wound. But having the "Catechism" in mind, I looked into the motor and found it to be a compound-wound machine. I could not reverse the shunt winding alone because that would make the motor differential, and the only way I could see was to reverse the current in the armature by exchanging the leads to the brushholders.

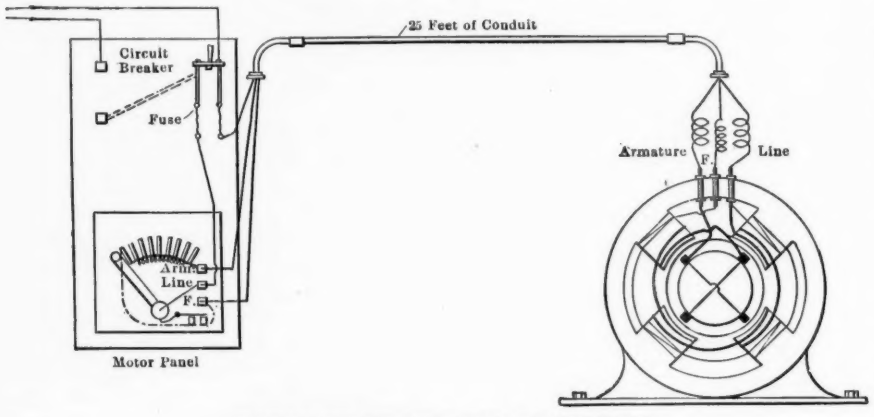


DIAGRAM FOR VERIFYING MOTOR CONNECTIONS

I started the motor up to find out which way it had been running and the starting lever touched the first contact on the faceplate of the starting box, and the motor started off at a furious rate; it seemed to me it turned up about 2000 revolutions per minute, when it should have run 450. I immediately pulled the switch and began looking for a break in the shunt-field circuit. Being unable to find any defect whatever in the circuit, I made a diagram of all of the connections of the motor, which is shown herewith. Owing to the conduit being so long, I had to use a test lamp to "prove" the diagram and in doing this I found that the main leads had been transposed at the motor. This showed me how the motor lost its shunt field. The shunt circuit from the starter to the field winding was all right, but the only return path was through the armature lead instead of the line lead; consequently the shunt winding was connected merely to the terminals of the starting resistance, and got practically no current.

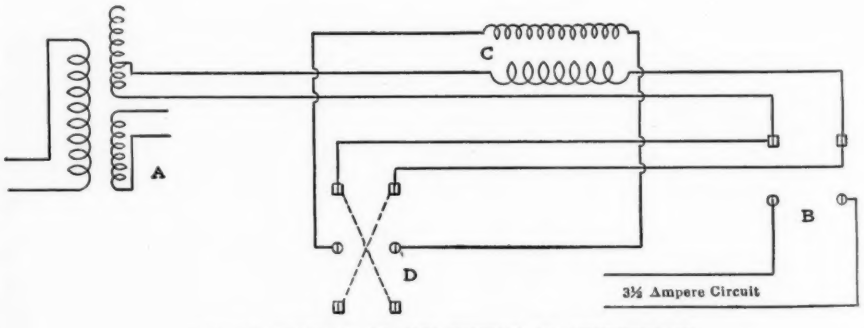
Changing the main leads back again straightened out the trouble and I then reversed the motor by transposing the brushholder cables. I found later that the wiremen had connected the motor up to try it and it had then been disconnected and moved away from its position. When put back it was turned around and the outside leads were connected up backward, as described.

R. E. OSBORN.

Toledo, O.

Puzzling Transformer Action

I submit herewith an electrical problem, hoping that some reader of POWER may be able to solve it. The accompanying diagram shows the wiring of one section of our switchboard which supplies current to a 3.5-ampere series incandescent lamp circuit for street lighting. The constant-current transformer *A* has two secondary windings, one of which supplies this circuit, and the other, through an inductance regulator, supplies a 6.6-ampere circuit not shown; *B* is the circuit switch; *C* is a 20 to 1 constant-potential transformer which may be connected so as to raise or lower the voltage impressed on the line, a double-throw switch *D* being provided to control the primary current in the transformer or to cut it out altogether, as required. The idea was to produce closer regulation than that given by the steps of the transformer *A*, which are too far apart.



WIRING DIAGRAM OF ONE SECTION OF SWITCHBOARD

When the switch *D* is closed upward the voltage is boosted, but when closed downward, the transformer *C*, instead of lowering the voltage, boosts it 10 or 15 volts. The question is, why doesn't it buck?

I would esteem it a favor if some other reader would give me a correct explanation.

E. L. MASON.

Garnett, Kan.

Lifting Limitations of a Pump

In the reply to an inquiry in an issue of several months ago, it was stated that a pump will not raise water to the theoretical limit of 34 feet because of the "slippage" and the friction of the water against the pipe walls. This is correct and in the case of a pump designed as an ordinary single-action hand pump in which the bucket can be adjusted to work clear down to the valve, thus eliminating the clearance, your explanation is practically complete if the water is cool and the suction pipe air-tight.

In a pump made as a steam pump is ordinarily constructed there is another and greater reason for its failure to raise water to the theoretical hight, and that is its inability to create a perfect vacuum.

Take, for instance, a pump of such dimensions that the piston displacement is 1 cubic foot, and the cubic contents of the clearance between the piston and cylinder head and the space between the valve disks is 0.25 foot. Then when the piston is at one end of the cylinder and moves to the other the 0.25 cubic foot of air in the suction end would be expanded to 1.25 cubic feet at 3 pounds pressure if there were no suction pipe on the pump and the opening for it closed. Of course this would not be the condition in pumping, and air would be taken from the suction pipe as that in the cylinder is rarefied, but under no circumstances could the air in the cylinder, and consequently in the suction pipe, become less than 3 pounds; therefore, the effective air pressure to raise the water would be but $15 - 3 = 12$ pounds, enough to balance a head of about 27 feet, and the pump could not raise water by suction to exceed this distance even if all other conditions were as nearly perfect as it is possible to make them. We know 15 pounds is not exactly cor-

rect for the air pressure, but this does not affect the principle.

In many pumps the clearance is greater in proportion to the piston displacement than 1:4—the ratio we have considered here—with a consequent lowering of the pump's efficiency in raising water by suction.

FRANK L. WALLIS.

Des Moines, Iowa.

[Mr. Wallis' argument would apply to a pump starting up with no water in the suction end of the system, but the condition on which it is based disappears when the pump is "primed," which is easily and commonly done.—EDITORS.]

The Surface Condenser

I noticed in your issue of February 16, page 351, an abstract of an article relating to condensing apparatus, which was published in the December 25, 1908, number of London *Engineering*. I submit herewith a copy of a letter which I have forwarded to the editor of *Engineering*, commenting upon the article in question, as follows:

"I was much astonished at the article which appeared in the issue of December 25, 1908, of London *Engineering*, in which the statements were made that the economy to be gained by the increase of vacuum from 24 inches to 28 inches was approximately 17 per cent. on steam turbines, and with the reciprocating engine the same increase of vacuum would result in a saving of only 2 per cent.; and that, in order to utilize such a high vacuum, the low-pressure cylinder would have to be built rivaling Captain Ericsson's 14-foot hot-air engine cylinder, and the small economy gained by the increase in vacuum is given as an excuse why the average marine engineer regards low vacuum as justifiable. It appears to the writer that the statements made in this article are not in accordance with the facts and that the use of low vacua as mentioned in marine practice is an exception and, instead of being justified by economy, is only an excuse for badly designed condensing apparatus or a lazy engineering department.

"In looking for data on existing practice regarding the best vacua to carry, I have made some investigations among the transatlantic liners, and the best ships with reciprocating engines are carrying from 26 to 28 and more inches of vacuum. Where the results are looked into, the engineers are required to keep the vacuum system tight and carry all the vacuum they can get, and while it is true that greater benefits can be derived from high vacua in a steam turbine than in a reciprocating engine, it is also true that, where primary heaters are not used, the higher the vacuum carried the greater is the justifiable economy which can be obtained from the plant. The Allis-Chalmers Company, of Milwaukee, Wis., has built more pumping engines than any other firm in the United States and has earned large sums for producing results better than those guaranteed, and the higher vacua have played an important part in those results.

"While the writer was chief operating engineer of the Interborough Rapid Transit Company, New York City, we changed the motor-driven air pump and jet condenser for a barometric type of condenser and increased the vacuum on each of the 8000-horsepower Allis-Chalmers horizontal vertical engines at the Seventy-fourth street station from 26 inches to 28 inches, thereby increasing the power on each of the eight units approximately 275 horsepower, and the economy of the station was increased very nearly in the same ratio. This change was made about seven years ago and the plant is still operating with 28 inches of vacuum, the vacuum being measured with mercury columns connected to the exhaust pipe at a point just below the exhaust nozzle of the low-pressure cylinders.

"A careful test made on the Fifty-ninth street station of the Interborough company showed a decrease in steam consumption of 8 per cent. when the vacuum was raised from 25 to 28 inches. These engines drive 5000-kilowatt generators and the test was very carefully conducted. In view of the results obtained by the test just mentioned, the writer questions the statements made that an increase from 24 to 28 inches of vacuum results in the saving of only 2 per cent.

"The South Side Elevated Railway in South Chicago has 4000-horsepower units on which is carried 28 inches of vacuum and has been for the past three years, and we could give many other instances where high vacua are being carried on reciprocating engines with economical results, sufficient to justify the installation of the high-vacuum apparatus.

"It is true that eternal vigilance is required to keep air leaks out of the system, but the writer submits that it is cheaper to keep the system tight than it is to pump large quantities of air or, what is ordinarily done, run on low vacua.

"Operating on low vacua is due to one of three things: Either the condensing apparatus is not suitable for its work, a lazy engineering department, or the policy on the part of the management which will not furnish help enough properly to maintain the plant in good operating condition.

"The remarks in the article relating to vacuum gages are, unfortunately, true and the writer has yet to find a vacuum gage that will stay correct for any great length of time, but, in American practice, in any well-managed station, mercury columns are provided to check up the gages and the gages are used only as an approximate check on operating conditions. In the larger stations, mercury columns are attached to each unit so that a correct observation can be made at any time."

R. D. TOMLINSON.

Milwaukee, Wis.

As to Increase of Salary

An engineer asked me not long ago if I thought it proper for him to ask his employers for an increase of salary. The question looked simple enough, but before giving him my answer I asked him why he thought he was worth more. He replied that the man they had before him received $200 per year more than they were paying him, and the "boss" took delight in telling of paying his old engineer $35 per week, although he was saving him $50 per week over the running expenses of the former engineer.

He said he always made it a point not to ask for an increase, but always tried to show his employers by his work that he was worth all they could afford to pay.

I should like to have the opinion of POWER readers in regard to this question. Is it proper to ask for an increase of pay?

CHARLES W. MITCHELL.

Sharon, Penn.

The Cummer Engine

The very comprehensive articles on "Setting the Valves of the Cummer Engine," in the December, 1908, and January, 1909, numbers, by Messrs. Allen, Collins and Francis, I found very interesting. To my mind there never was placed on the market an automatic engine with better material, finish and capability of withstanding hard service with the same economy and less vexation to keep up than the old Cummer, an engine that has won much praise from those who have known its performance. The only reason I can assign for its not being more prominently known and used is its having peculiar valves and governor.

I had charge of a 12x30 Cummer engine for nearly ten years and have often wondered how many hours of thinking, reasoning and experimenting the inventor had put in while designing the engine.

The articles referred to are so clear and concise that no one who ever ran a Cummer engine can doubt for a moment that the advice and instruction contained in those articles alone are worth more than a year's subscription to POWER.

My old Cummer has been displaced by a Corliss engine in order to provide for an increased demand for more power.

S. M. GASTON.

Sherman, Tex.

Refrigerating Plant in Steel Works

Largest Plant in Existence for Drying Air Supply to Blowing Engines; Saves $1 a Ton in Making Pig Iron and Produces More Uniform Output

BY OSBORN MONNETT

It is but recently that the subject of water vapor held in the atmosphere has had any attention with reference to its effect on the operation of blast furnaces. While it has long been realized that all air in its natural state contains water vapor in varying quantities, depending on the temperature and the opportunity which the air has had for acquiring moisture, it was for a long time considered that this was one of the insurmountable difficulties and drawbacks in furnace operation, although all the other elements which go toward the making of steel have had careful consideration for many years.

Advantages of Using Dry Air

At the late meeting of the American Society of Refrigerating Engineers, held in New York City, Bruce Walter, who has been connected with developments in this line from the beginning, brought out many interesting facts based on experience with refrigerating outfits in several different plants. It appears that there are required approximately two tons of ore, one-half ton of limestone and one and one-half tons of coke, to make a ton of iron. In addition to this, five tons of atmospheric air is required to furnish the necessary oxygen. In this enormous quantity of air it can be readily seen that the moisture will be a great disturbing factor. Irregularity in moisture content of the atmosphere under different conditions not only changes the quantity of oxygen delivered from time to time according to the humidity, but each pound of the moisture requires something like 13,000 B.t.u. to decompose it into oxygen and hydrogen. This, of course, reduces the efficiency of the furnace, requires more coke and interferes with the regularity of the output.

In 1897 the Carnegie Steel Company began experimenting under the supervision of James Gayley, who is the inventor of the Gayley dry-blast process, with a view to determining the approximate cost of removing the moisture by means of refrigeration.

Subsequently at the Isabella plant of the United States Steel Corporation, located at Etna, Penn., a large outfit for removing moisture from the air was installed and the results have been highly satisfactory to steel men. The coke saving has been shown to be about 350 pounds per ton of iron, the daily output increased about 10 per cent., the iron produced is more regular in quality, and less air is required, due to the decreased temperature and consequent smaller volume. An

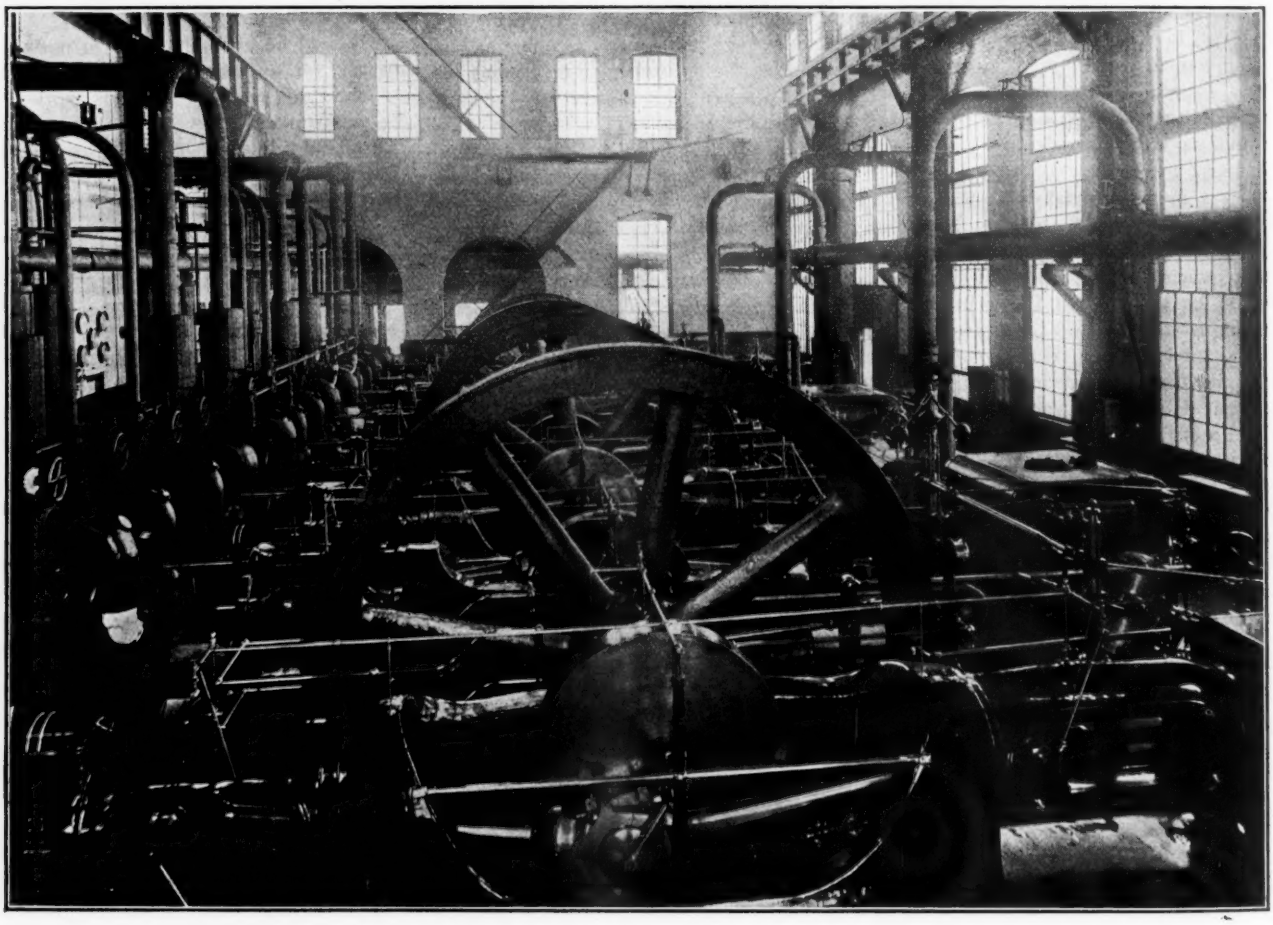


FIG. I. GENERAL VIEW OF COMPRESSOR ROOM

interesting point in this connection is that the saving in steam used by the blowing engines has been found to exceed the amount of steam taken by the refrigerating equipment. Incidentally there is also a decrease in the quantity of limestone required owing to the fact that the reduction of the amount of coke reduces the ash, and less lime is required to take care of it.

Experience at the Isabella plant and elsewhere, both in this country and Europe, has determined that there is an average decrease of cost in the manufacture of pig iron of approximately $1 per ton, due to the application of dry air. Although this is a great advantage, a still greater one is the fact that the quality of the output can be depended upon to be more nearly uniform than when using natural air. The quantity of water removed from the air supplied to a blast furnace making 450 tons of iron per day is said to be 5000 or 6000 gallons in 24 hours, when the humidity is greatest.

As the amount of moisture in the air varies from 0.5 grain per cubic foot on a cold day in winter to 9.5 grains per cubic foot in mid-summer, it can be seen that the load on the refrigerating equipment will vary considerably, so that the average amount of steam required is much less than that called for by the full capacity rating of the machines. This explains why the saving in steam required by the blowing engines, which operate continuously with cold air of corresponding small volume, is more than sufficient to operate the ammonia compressors.

1200-TON REFRIGERATING PLANT

Recently there has been put in operation at the South Works of the Illinois Steel Company, at South Chicago, the large refrigerating plant shown in the accompanying illustrations. The plant, which is capable of drying 122,000 cubic feet of air per minute, and is the largest that has so far been installed for this purpose, consists of four refrigerating machines of 300 tons capacity each, of the duplex horizontal type. Each machine consists of a cross-compound condensing Corliss engine and two ammonia compressors placed opposite the high- and low-pressure steam cylinders.

Fig. 1 shows a general view of the machines. They are located in a building 102 feet long and 53 feet wide, which is spanned by an electric traveling crane. A 16-inch steam main extends the length of the building at one side, resting on brackets and roller bearings to take care of expansion. From the top of this header a steam connection is made to each of the units through long-sweep bends. The compressors, together with the ammonia condensers, brine coolers and accessories were supplied and installed by the Vilter Manufacturing Company, of Milwaukee, Wis. The steam ends of the machines consist of the Vilter standard Corliss-engine design, with a single eccentric actuating a wristplate from which the valve motion is derived. The governors, which are of the regular flyball pattern, control the cutoff on both the high- and low-pressure sides. They are provided with an automatic stop and are operated by a governor pulley belted from the main shaft.

As will be seen in the illustration, the frames are of the heavy-duty type, and the compressors get their action from the main crank pins. Forced lubrication is used on the piston rods of the compressors, and for the various bearings a complete Nugent oiling system is installed. The steam cylinders are 24x46 inches in diameter and have a stroke of 36 inches, while the compressor cylinders are 18 inches in diameter with a 36-inch stroke. The latter are provided with a set of two suction and two discharge valves. The compressor heads are turned to a true hemisphere and the pistons and valves conform to the same curvature, this construction admitting of large valve area and small clearance. Provision is made for preventing the suction valves from falling into the cylinders in case of the breaking of a valve stem. In the compressors the cylinder barrels proper are made of semisteel castings pressed into the cylinder by hydraulic pressure and bored and finished at the same time as the guides, to insure alinement, the space be-

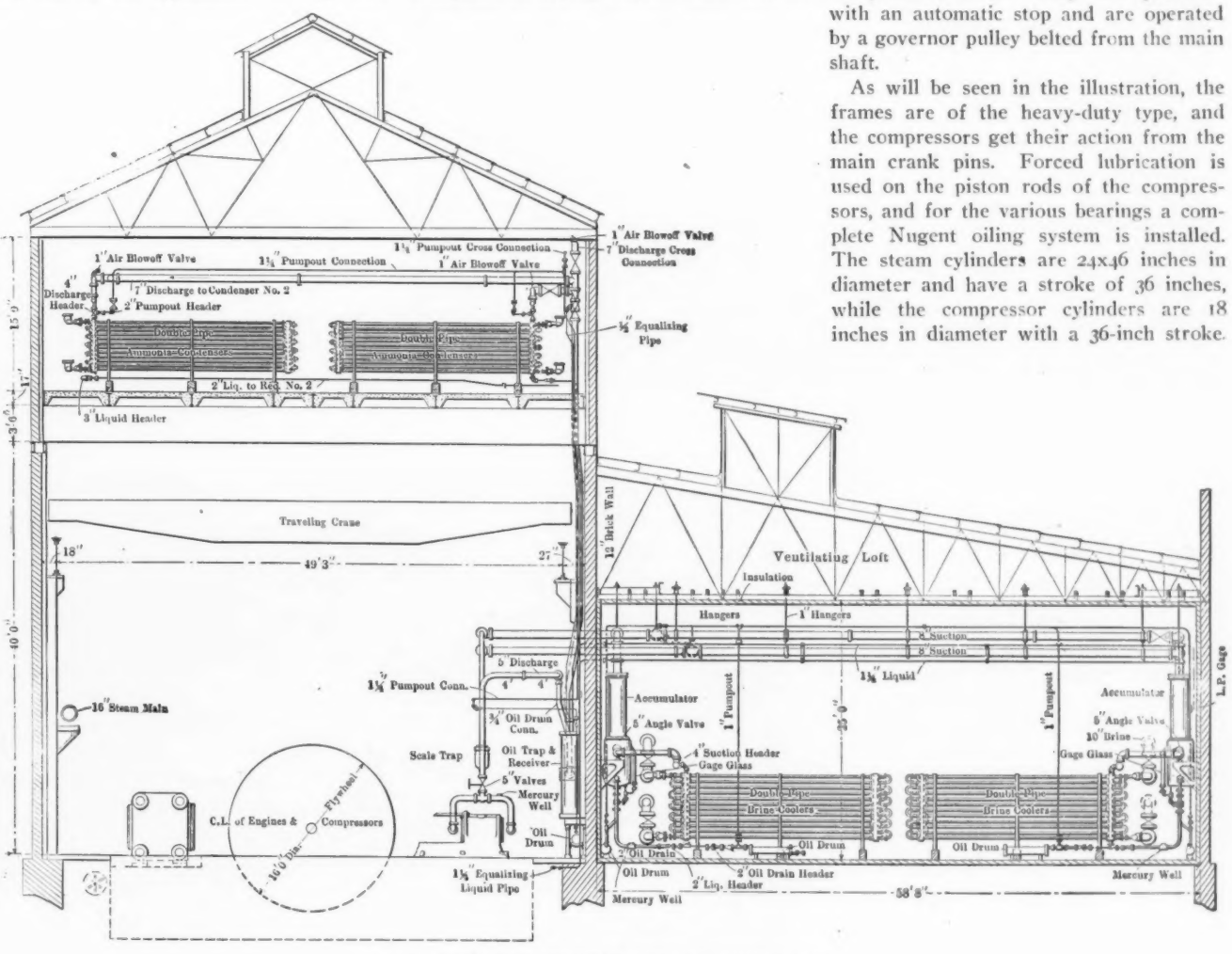


FIG. 2. ELEVATION THROUGH REFRIGERATING PLANT

tween the cylinder jacket and cylinder proper forming the water jacket.

Double-pipe Condensing and Brine-cooling Systems

Discharging from the compressors, the gases pass through oil traps, of which one is provided for each machine, and enter the condensers, which are located on the second floor of the building, as shown in the elevation, Fig. 2. These condensers are of the double-pipe type, consisting of 2-inch pipes 18 feet long with 1¼-inch pipes passing through them for circulation of the cooling water. Twenty-five stands of such double-pipe condensers grouped 12 pipes high are provided for each machine, making in all 100 stands. Fig. 3 is a photograph of this part of the installation. Although each condenser ordinarily operates with its individual compressor, connections are so arranged as to permit the operation of two or more of them in combination on all or part of the condenser system.

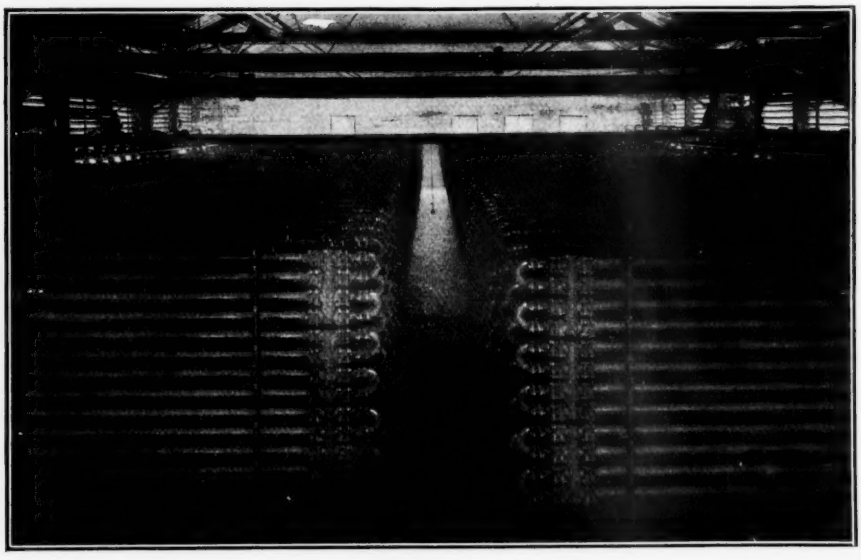


FIG. 3. AMMONIA CONDENSER ROOM

Four receivers collect the liquefied gas and carry it through individual pipes to the cooling apparatus in which the liquid ammonia is expanded, thereby extracting the heat from the brine.

The double-pipe system is also used in cooling the brine and consists of four batteries of 20 stands each. Each stand has twelve 3-inch pipes with 2-inch pipes passing through them. This apparatus is installed in a building adjoining the compressor room and shown in Fig. 4, which is 68 feet 4 inches long by 58 feet 8 inches wide and 25 feet high. The floor, walls and ceiling are insulated with a double layer of 2-inch cork board. A saturated solution of calcium chloride is used as the cooling medium. This is forced through the inner pipes and transmits its heat to the liquid ammonia in the annular space on the interior of the 3-inch pipes.

Novel Method of Introducing Refrigerant to Cooling Coils

One of the features of this part of the installation is that relating to the method by which the liquid refrigerant is introduced to the double-pipe cooling coils. In usual practice this is accomplished by needle valves or expansion cocks attached to the supply side of each double-pipe system, and the expansion is regulated as nearly as possible, so that each set of cooling stands receives its requisite amount of ammonia according to the demands on the system. Unless this regulation is very accurate, there will be some of the surface left ineffective for lack of liquid ammonia to which heat can be transmitted, or more or less of the ammonia will pass through the apparatus in a liquid state, thus materially decreasing the capacity.

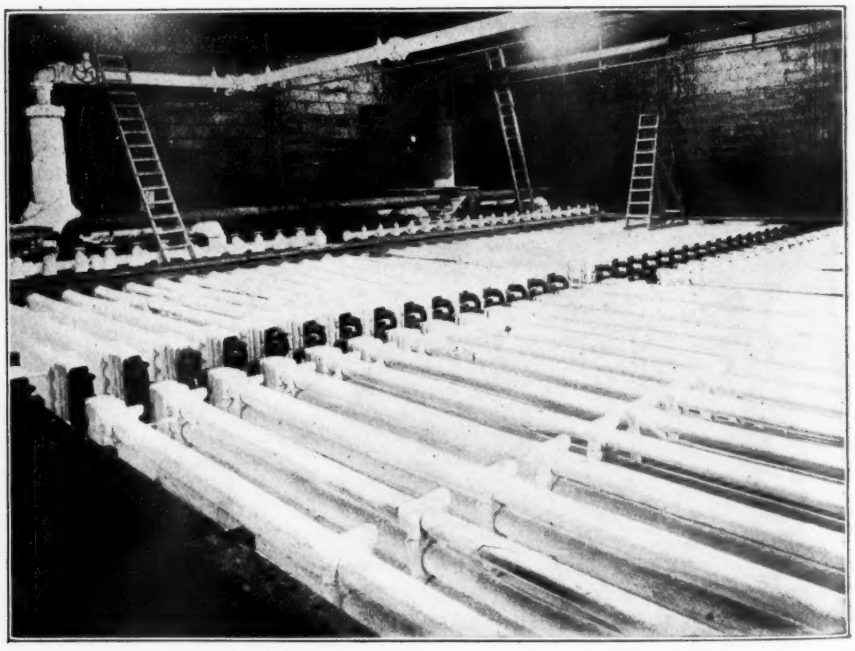


FIG. 4. DOUBLE-PIPE BRINE COOLERS

In this installation there is an elevated receptacle called an accumulator for each battery of cooling coils. As shown in the drawing, Fig. 2, these accumulators are placed at such hight that liquid ammonia will flow through the cooling coils entirely by gravity. In the upper part of each accumulator is a coil through which circulates the liquid ammonia from the condensers. The cold expanded gas passes out through this part of the accumulator on its way to the compressors and cools the incoming ammonia.

After being cooled, the ammonia is liberated through a valve and allowed to run into the bottom part of the accumulator where it is subjected to suction pressure only. The success of the procedure depends upon relieving the liquid ammonia of its excess of sensible heat before it is allowed to pass to the accumulator. Therefore, there is no evaporation when the ammonia passes from the condensing pressure to that due to the suction pressure on the system.

After passing into the bottom of the accumulator the liquid ammonia flows by gravity to the double-pipe brine coolers, flooding them with liquid. The exchange of heat is then obtained by a boiling process rather than by instantaneous expansion as with other systems. As the liquid in the coils absorbs the heat from the warmer brine, it boils, the same as water would boil in a steam boiler, and the gaseous ammonia thereby formed makes its way to the outlet of the coil which, as shown in Fig. 2, connects with the accumulator at a point just above the level of the liquid. In case any liquid am-

monia should pass through, it immediately drops into the bottom of the accumulator and is circulated again until it has absorbed its quota of heat and is expanded into gas. The gas then ascends into a large pipe header which terminates in a separator before returning to the compressor cylinders.

Cooling the Air

An important part of the work of this installation is circulating the cold brine through the coils where the air is cooled before going to the blowing engines. For this work there are three Prescott Corliss cross-compound, flywheel-type pumping engines installed. Each has a capacity of 1200 gallons per minute when operating with 120 pounds of steam. The pumps have steam cylinders 12½x24 inches in diameter and plungers 8¼ inches, all with a common stroke of 24 inches. These pumps were especially designed to take care of brine at the low temperature required in this plant, and particular care was taken to avoid shrinkage in the castings, considerable more metal being allowed in the pump sections than is ordinarily the case.

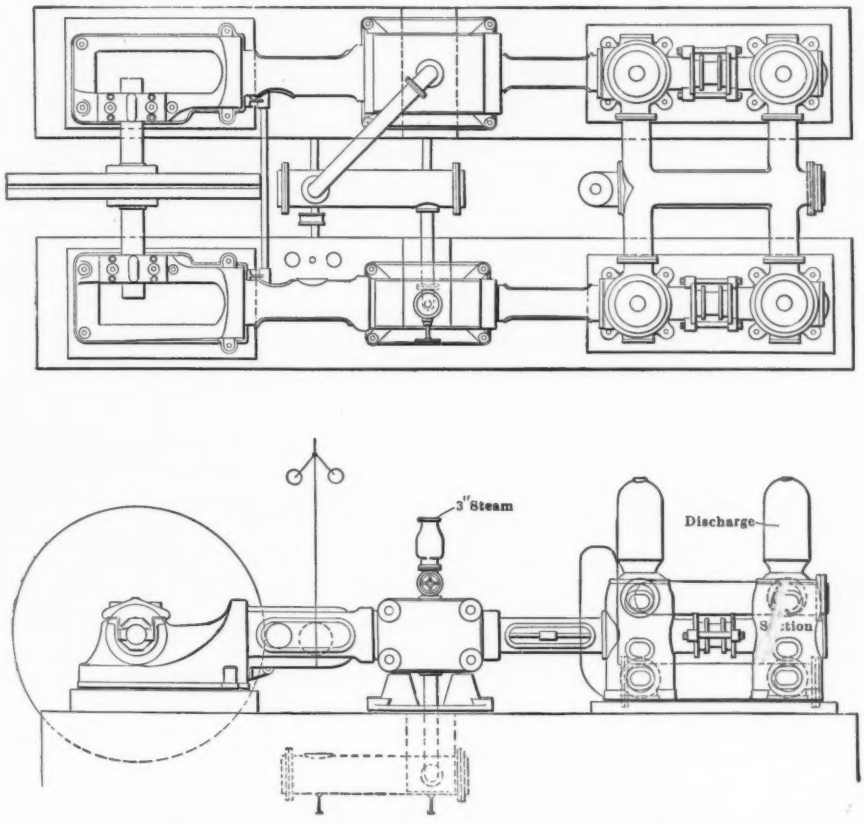


FIG. 5. CROSS-COMPOUND PUMP FOR CIRCULATING BRINE

Each suction and discharge deck contains seven 4-inch valves with a total area of 70 square inches, which gives a velocity of 2.8 feet per second through the valve seats. A suction pressure of 25 pounds is carried on the system. The brine enters the air-cooling coils at about 16 degrees Fahrenheit and returns to the pumps at 32 degrees.

A separate structure is provided in which to cool the air. This is a building 47 feet 10 inches by 66 feet 10 inches in ground plan and is divided by brick walls into seven compartments. In each compartment are immense coils of 2-inch pipe, 40 feet long and 200 pipes high. The coils are staggered in order to bring the air into contact with all the cooling surface and are connected with brine headers on the top and bottom. Brine enters at the top and flows downward in the opposite direction to that of the air. Ducts on each side of the building in the basement distribute the air to the compartments, which are controlled by inlet gates. The air is blown into these ducts by two motor-driven fans, forced up through the cooling coils and out of the top of each compartment at a temperature of 32 degrees, where it is collected in an 8-foot conduit leading to the blowing engines.

As the moisture is removed from the air it collects on the coils in the form of frost, and it is arranged so that the compartments may be taken out of service one at a time for the purpose of thawing off this accumulation after it has reached a certain thickness. To do this the compartment is isolated by closing the top and bottom gates, the brine is drawn off into storage tanks and water is sprinkled on the coils until the frost is removed, when the compartment can again be put into service.

Single-versus Four-valve Engines

Although many conditions may enter to offset the relative merits of single- and four-valve engines, the following conclusions reached by F. W. Dean, mill engineer and architect, Boston, Mass., as the result of a series of comparative tests are certainly instructive as regards economy. The engines in the series were all simple, of the high-speed type, direct-connected to electric generators and ranging in size from 12x18 to 16x15. They had all been run under working conditions for a considerable period, with one exception, exceeding 5000 hours.

The most important conclusion reached is that the four-valve engines, which were built to be more economical than single-valve engines, utterly failed in their object. The results show that efforts to realize economy by duplication, or multiplication of parts, even if ports are shortened and clearances reduced, accomplish nothing. The duplication of valves used in the four-valve engines under test simply increased the opportunity for leakage. Mr. Dean asserts that it is doubtful if the four-valve type is tight even when new, and that it has no chance of ever being tight thereafter unless it is refitted, which is seldom done. This type of valve must take the whole responsibility of the extravagance of the four-valve engines. He does not hesitate to advise builders to abandon four valves on high-speed engines unless they are prepared to build a really high-class engine having four Corliss or gridiron valves made and fitted in the best manner. Even then it would be necessary for them to prove their case. Steam engines of whatever type should have valves that are not only tight originally, but that should become so by wear if they are not so originally. The wearing process should be a tightening process.

A bulletin has just been issued in the engineering series of the *Bulletin* of the University of Wisconsin, under the title, "Current Practice in Steam Engine Design." The monograph was prepared under the direction of the late Storm Bull, professor of steam engineering, by O. N. Trooien. The book, which is intended for general distribution, contains forty-odd charts showing graphically the proportions, weights and dimensions of the essential parts of Corliss and high-speed automatic engines. It is the result of an investigation of considerable extent of steam engines of recent construction, and shows the changes that have taken place in the last ten years. It enables comparisons to be made between plans and drawings submitted and the minimum, average, and maximum weights and proportions in current practice. The bulletin also contains formulas for designing the essential parts of a steam engine.

Some Useful Lessons of Limewater

Practical Test for Hardness in Water; How to Soften Permanent-Hardness Water; Explanation of the Reaction in Water Softening

BY CHARLES S. PALMER

In last week's instalment we noted one test with barium solution for telling the difference between temporary-hardness water and permanent-hardness water. That is what would be called a chemical test, and it means a great deal, for it uses the insoluble white barium sulphate for finding sulphuric acid (or soluble salts of the acid, called sulphates). All that is good; but it is only an explanation of what you know already about the practical testing of hard water.

Practical Test for Hardness

You take a piece of soap to test for "hardness" in water. If the soap will not make a quick lather and, worse still, if the soap causes that greasy scum to form in and on the water, which you know is called "lime soap," then you know that the water is hard. That is the first step in testing hard water practically. The next step is to find out whether the water will become soft by simple heating and settling; if it will become soft by heating (and now you know that this is only changing the extra or bicarbonate of lime or calcium, which is soluble, to the insoluble plain carbonate), if the water does this on simple heating, then you know that the hardness is only temporary; it can be got rid of in ways that are comparatively easy. But, if the hardness of the water is not improved by heating and settling, if the soap still refuses to lather quickly, and if that greasy lime soap still comes in the water after the heating and settling, then you can be sure that you have "permanent" hardness.

This permanent hardness is harder to remove than the temporary hardness, and for several reasons. The chemical test that you gave the water at the end of the article in February 16 showed you that the permanent hardness is due to calcium sulphate, $CaSO_4$. Now the sulphates are all "salts" of sulphuric acid, oil of vitriol; and one quality of this sulphuric acid is that it is not easily volatile, as carbonic acid is; and another quality is that it is a strong and stable acid. In the case of the lime carbonate, we added extra carbonic acid from the breath; and we drove it off again by simple heating. But in the case of sulphuric acid you are dealing with a stronger, a more stable and a less volatile acid than carbonic acid; and that tells some of the reasons why temporary hardness, or "carbonate hardness," as it may be called, is so much easier to get rid of than permanent hardness, or "sulphate hardness." In both cases, you will have to do mainly with lime-like compounds for the basic part of the "hard" salts, although there are also salts of sodium, of magnesium and so on, in hard water; but the big difference between the temporary or carbonate hardness and the permanent or sulphate hardness will be found to lie in the difference between the instability of the carbonates and the stability of the sulphates. Let us get some experiments with this other kind of lime-like salts, the sulphates, which are found in permanent-hardness water.

The first thing to do is to make some of this permanent-hardness water. You can do this in several ways. One way is to shake up a little common plaster of paris in a tumbler of water, and after some minutes filter off the clear solution. Plaster of paris is nothing more than calcium sulphate (sulphate of lime), and it is thirsty for water. That is the reason why it is used for making all sorts of things where a quick-drying paste is wanted; and that is also why plaster of paris is called "anhydrous," which means "without water" but willing to unite with it. You will filter the solution of this plaster of paris to get a sample of artificial permanent-hardness water, or you can make it in another way.

Go back to that solution of plain limewater. Slip a strip of your litmus paper down the side of a tumbler and fill it half or two-thirds full of filtered limewater. You note that the litmus paper is blue; and that reminds you that the limewater is alkaline or strongly basic. Now take the bottle of sulphuric acid and carefully drop in a drop or two of sulphuric acid, not too much, stirring with a piece of the glass rod which came with your outfit. Bring the sulphuric acid and limewater to neutrality, so that it makes the litmus paper neither red by acid nor blue by the alkaline limewater, but neutral purple. You can get this point by several trials; and it is worth your while to get it and get it right. You may find that the sulphuric acid is too strong for the limewater, and that a few drops of the acid will more than neutralize a half tumbler of the limewater; in that case, your wits will tell you to pour out a few drops of the acid into another tumbler of water, and then to use this second tumbler of diluted acid to neutralize the limewater. But, when you do get the limewater and the sulphuric acid together, neutralized and filtered, you will have the same thing as the filtered solution of plaster of paris, and both will be nothing more than artificial permanent-hardness water. And if you don't believe that this kind of water is permanently hard, just try to get rid of that lime-like part quickly, easily and cheaply. It can be done, in some cases, and perhaps in all cases; but it is part of the object of these lessons to see what the difficulties are, or rather what the possibilities of help are. You know what the troubles are.

Softening Permanent-hardness Water

Well, here is your solution of permanent-hardness water, or sulphate water. Tease it with every test that you used with limewater and lime-carbonate water. You will probably get no precipitate with carbonic acid, whether taken from the breath, from the glowing coal, from the bottle of "fizz," or from the apparatus shown in the February 9 number, where you made carbonic acid from marble or soda and hydrochloric acid. The calcium sulphate which makes the scale, the hard scale, in permanent-hardness water is more soluble than the theoretically possible lime carbonate which might come down by blowing through some carbonic-acid gas; but the hard water does not give down its lime sulphate as easily as that. The reason why the carbonic-acid gas from the breath, or from any of the other sources that you used, does not throw down the lime as calcium sulphate seems to be that as the carbonic acid would take hold of the lime, the sulphuric acid would have to step out; but this same sulphuric acid would not remain free in any quantity but turn round and attack the lime carbonate formed somewhat; and so the possible reaction would work backward; at any rate it does not work to soften the water.

But this has given you an idea; if plain carbonic-acid gas will not throw down the lime from lime sulphate, why not put in something with the carbonic acid, something like a base, to take care of the sulphuric acid that will be set free? Why not try something like soda carbonate, soda ash, or the like? You will find that this will make an interesting experiment; and it will block out the way for some good thinking.

Make a pint or so of this filtered solution of plaster of paris, then add a pinch of soda ash; shake the water well, and let it settle. Do not filter this, but let it take its time to settle by itself. While the

stuff is settling, you can study the following equation of the reaction:

Explanation of Reaction in Softening Water

You will notice that the "salt" lime (or calcium) sulphate has two parts, a basic part and an acid part, and a similar thing is true of the "salt" sodium carbonate, that you add to the hard water to soften it. You can straighten it out and remember it at the same time, in this way: Write out the names of the substances, underlining the base parts, and overlining the acid parts, thus:

$$\left.\begin{matrix}\underline{\text{Calcium}}\ \overline{\text{Sulphate}} \\ \text{Soluble}\end{matrix}\right\} + \left\{\begin{matrix}\underline{\text{Sodium}}\ \overline{\text{Carbonate}} \\ \text{Soluble}\end{matrix}\right.$$

equals

$$\left.\begin{matrix}\underline{\text{Calcium}}\ \overline{\text{Carbonate}} \\ \text{Insoluble}\end{matrix}\right\} + \left\{\begin{matrix}\underline{\text{Sodium}}\ \overline{\text{Sulphate}} \\ \text{Soluble}\end{matrix}\right.$$

You see that the exchange between the salts is much like dancing couples exchanging partners. Each "salt" has its acid part and its basic part, and the parts simply exchange places, with the selective affinity necessary to make one of the salts insoluble; that is, the lime carbonate. Thus you have driven the lime out of solution, and while you have done this, you have also left another soluble salt in the water, that is sodium sulphate. It is like driving out a plug by another plug; but still one plug stays in the log. But in the case of the temporary-hardness water, in changing the extra carbonate to the plain carbonate you drove out both plugs at the same time. Here, in the case of the permanent hardness, the plug which stays in the log is the soluble sodium sulphate.

But, you ask, what is the harm of leaving some of this sodium sulphate in the boiler water? Well, what is the harm of leaving such a soluble thing as sulphate of soda, which you know already as Glauber's salt, in the boiler water? Because, as you well know, such salts may cause priming, not to mention the possibility of their helping on the corrosion of the metal of the boiler and its connecting pipes. So there you are; and you begin to see what are some of the annoying problems connected with this general subject of water softeners.

Now this lime (or calcium) sulphate is soluble in water, one part to some four or five hundred parts of water, if the solution is loaded to the limit. Soda, which is sodium carbonate, is very soluble; and if you add this water softener in the comparatively cheap form of soda ash, you will still need a settling tank for the lime carbonate to settle out clear. Also, the boiling water will have to be blown off frequently, to say nothing of looking out for the foaming and priming that wait on the poor boiler man to give him his full share of trouble.

Carefulness in Experiments

There is one thing that should be mentioned here regarding the action of chemicals on each other; that is, that any description of the actual happening is and can be only approximate to what does actually happen. If you alter any of the conditions, as the quantity of the water or other solvent used, or if you change the temperature, or the quantity or purity of the chemicals used, naturally the results will vary slightly. This does not mean that nothing definite will happen, but it does mean that little things will vary the general results, and each experimenter will have to keep his own eyes open to see just what does actually happen in the case of the chemicals he is using in his laboratory. Do not misunderstand me. There is no uncertainty as to conditions or results; but there may be the greatest variety in the conditions and results, and things that one may call little or of slight importance may make things appear to change greatly. But, remember this: When you and I may differ as to what does happen, nothing is easier than for each of us to try it for himself; then we will find out without depending on the books to see for us.

Explanation of Slacking Quicklime

We have found out some interesting things about this substance, lime; and yet, there is so much to examine and to discuss that we have had to overlook many things that are both interesting and practical. One of these is the "slacking" of "quicklime." You have often seen masons getting their mortar ready, and you have seen the white, muddy mass fairly boil with heat as the lime is mixed with water. Indeed, this heat of slacking lime is so strong that, as you well know, fires may be easily caused by leaving barrels of quicklime in exposed places in or near wooden buildings; and the question comes up right here: What is the slacking of lime? What is the difference between quicklime and slacked lime?

Practically, the difference is due to the action of water. Water consists of hydrogen, two parts, and oxygen, one part; and we tell this long story in the short and curious way implied in the formula, H_2O, which is read thus: "H - two - O;" that is, there are two chemical units of the element hydrogen and only one part or chemical unit of the element oxygen. So you learn the formula of water as H_2O. Now you already know that quicklime is the rust of the metal calcium; and that is told in the form CaO, which is read: "C - a - O," Ca standing for the chemical unit of calcium, and O standing for the chemical unit of oxygen. You can write the action of water on quicklime this way:

Quicklime plus Water equals Slacked Lime, plus Considerable Heat:

or you can write the same story with symbols in this way:

$$\left.\begin{matrix}\text{CaO} \\ \text{Calcium Oxide}\end{matrix}\right\} + \left\{\begin{matrix}\text{H}_2\text{O} \\ \text{Water}\end{matrix}\right\} = \left\{\begin{matrix}\text{Ca(OH)}_2 \\ \text{Calcium Hydroxide}\end{matrix}\right\} + \left\{\text{Considerable Heat}\right.$$

As you look at them, there does not seem to be much difference between quicklime and slacked lime; but as you remember that the difference is enough to set a house on fire, evidently it is worth considering. The difference practically is evidently the adding of water to quicklime; but the quicklime is what is called "a base anhydride;" that is, it is a base minus water; and in some curious way this takes on water, splits it into several parts, rearranges these parts with the calcium and oxygen and forms the quiet base, calcium hydroxide (or calcium hydrate) $Ca(OH)_2$. It is apparently an important difference, this between the base anhydride as quicklime and the base proper, calcium hydroxide; and you will find this same difference between scores of other bases and their anhydrides. But it is interesting to know that this common quicklime is the only common, available and active base anhydride. When you dissolve some quicklime in water, it first takes on water forming the base proper, slacked lime (calcium hydroxide or hydrate), and then this dissolves in the water; so that probably it is not possible to have a solution of quicklime as such, CaO; but you will get rather a solution of the real base, slacked lime, $Ca(OH)_2$. In much the same way, you will find that some acids have the two forms, the anhydride alone on the one hand, and on the other hand the anhydride-*with*-the-ingredients-of-water, making the real acid. This is true of sulphuric acid, of nitric acid, of phosphoric acid (which gives you a chance to get an acid anhydride as active in its way as quicklime is a base anhydride in its way) and, especially, silicic acid.

The story of silicic acid starts from common sand, which is the acid anhydride of silicic acid. You would hardly guess that clean white sand is a latent acid anhydride, from the indifference it shows to water and everything else ordinarily; and this is traced out in most ingenious ways. But just think of what you have actually seen in the common blast furnace, the common foundry cupola, or even your own furnace, with its slaggy cinders, all only so many "salts" of this silicic acid in sand combined with such bases as your friend lime, or aluminum (the clay metal), or iron rust, and so on. You can try a good experiment with this acid of sand right in your boiler room. Lay a big lump of lime in one corner of your grates; if let alone it will stay there; it is infusible. Get a shovel of clean sand and put it in another corner of your furnace grates; it will stay there, for it is also infusible. But, mix the two, the base-anhydride quicklime and the silicic-acid anhydride,

sand, and pretty soon you will see the fire fuse the two together, making a clean melt in the liquid molten slag, which is a lime or calcium silicate.

You see this tendency toward the making of slag in every shovelful of your cinder; and now you begin to see that there are several fields of chemical action: there is the water field, sometimes called the field of "wet" chemistry; and there is the field of hot molten fusion, sometimes called the field of "dry" chemistry. Most elements have special relations with both fields, and this is particularly true of the substance lime. In the first place, it is made by burning limestone, driving off the volatile carbonic acid and leaving the base anhydride, quicklime. Then you dissolved this quicklime in water forming the true base, slacked lime, in limewater, or calcium hydroxide (the word "hydroxide" means that it has some of both hydrogen and oxygen). Then by blowing in carbonic-acid gas, you drove this calcium hydroxide, or limewater, to the plain insoluble carbonate, the same thing as limestone. Then by more carbonic-acid gas you forced this plain insoluble calcium carbonate over to the soluble extra or bicarbonate of calcium. Then you drove it back to the insoluble plain carbonate, by heating and settling. You also brought back the soluble bicarbonate of calcium to the insoluble plain carbonate, by mixing it with some of the base limewater emulsion, the two averaging up as the plain carbonate of calcium, the result of water softening by Clark's process.

You also begin to get a glimpse of the permanent hardness of sulphate of calcium waters; and you found out that you can throw down the lime by the alkaline salt, common washing soda, or soda ash. By the way, you will be interested to learn that common cooking soda is the extra or bicarbonate salt of soda; and that can be changed to the plain carbonate (soda ash or washing soda) by heating dry for an hour or two at a heat considerably higher than boiling water, roughly about that of molten solder. You can do this in a saucer on your kitchen stove at home, or in the front part of your furnace. It is interesting to know that the extra or bicarbonate of sodium can be changed to the plain carbonate only by heating it in the dry way, while the similar lime bicarbonate salt can be changed to the plain carbonate by heating in the wet way, another curious illustration of the relations and differences pertaining to the fields of "dry" and "wet" chemistry.

Thus far we have had to do mainly with lime or calcium compounds in our study of hard water, although we have frequently referred to the fact that there are other substances which come in to complicate things. One of the other things which is important in hard water is the salts of magnesium, for this element is almost a chemical cousin of calcium.

There is also one other thing to which you may want to give some attention, and that is the collecting of samples of actual boiler scale from various boilers and from various waters. You will find that the scales from some of the waters can be entirely cut or dissolved in the hydrochloric (muriatic) acid; these are mostly the temporary-hardness waters; while some of the scale will not easily or completely dissolve in any of the acids which you have, these are mostly the scales of permanent-hardness waters; and this kind of testing is closely related to the test given at the close of the third paper of these lessons, in the February 16 number. And so we are gradually accumulating the familiarity with limewater that will carry us on to the clearer understanding of what hard water is and how it may be treated.

Catechism of Electricity

937. *If the thermometer readings in 936 were taken on Fahrenheit thermometers instead of on Centigrade thermometers, would the results be affected?*

They would. If, however, the Fahrenheit readings be converted into Centigrade by substitution in the formula $C° = 5 \div 9\ (F° - 32°)$, in which $C°$ represents degrees Centigrade and $F°$ denotes degrees Fahrenheit, and these new figures in the calculations, the results will be the same as before.

938. *How long does it require a motor working under full-load conditions to attain maximum temperatures in its various parts?*

Small motors attain their maximum temperatures sooner than larger motors. Ordinarily, about four hours is sufficient for small motors and from six to eight hours for large ones.

939. *Is it possible to detect abnormal heating in a motor by any method not yet mentioned?*

Yes, by the sense of smell. When the heating has reached this stage of development, the limit of safety has been far exceeded. Trouble asserting itself in this manner may usually be located in the field or armature coils as the insulation on these windings when subjected to undue heat gives forth a very pungent odor not easily mistaken. If the machine is not shut down at once, the trouble is liable to increase until smoke is visible and the damage irreparable.

940. *What are the general causes of abnormal heating at the commutator?*

Those defects which have previously been mentioned as causing sparking at the commutator will also raise its temperature. They constitute the general causes of abnormal heating at the commutator.

941. *How should these general causes of abnormal heating be removed?*

By removing the source of the sparking as previously explained.

942. *Does not the appearance of the commutator serve as a guide to the direct cause of the heating?*

It does if the trouble is with the commutator. For example, if there are burnt spots on the surface of the commutator, there is probably dirt or foreign matter on it which should be removed. If, when the current is applied, small sparks can be detected in the insulation between the commutator bars, there is either foreign matter between the bars or the insulation itself has become defective. In the former case the troublesome particles should be removed and in the latter case a new commutator will probably be necessary.

943. *Is a hot commutator sometimes caused by trouble in other parts of the motor?*

Yes.

944. *What usually causes the brushes to become abnormally heated?*

Loose connections in the brush holders or between the brush holders and the brush-holder cables, decomposition of the brushes at their contact surfaces, or carbon brushes of too high resistance.

945. *What should be done in case the brushes are of too high resistance?*

Some improvement may be noticed if the brush holders are set lower so as to make that portion of the carbon through which the current passes as short as possible. Other methods of correcting this trouble consist in providing brushes of larger cross-section, in using a greater number of brushes and brush holders on each stud, and in increasing the conductivity of the carbon brushes by using copper in one form or another in connection with them.

In case one of the carbon brushes is found to heat more than the others, a comparison between its resistance and that of one of the others will show at once if the difficulty lies in its conductivity. If its relative resistance is found to be high, advantage may be taken of any of the remedies just given for decreasing its resistance.

946. *To what cause can abnormal heating of the field coils usually be traced?*

To the passage through them of a larger current than they are designed to carry.

947. *What would be the heating effect if one of the field coils was short-circuited?*

The short-circuited coil would be cooler than the others, and its pole piece would be weaker magnetically.

948. *Is there a more accurate method*

of locating a short-circuited field coil than that mentioned in 947?

Yes. To make absolutely sure whether a field coil is short-circuited, measure the resistance of each one by the drop method. This consists in passing a direct current, maintained constant by means of a rheostat and ammeter, through the field coils connected in series and measuring by aid of a voltmeter the drop in pressure across the terminals of the individual coils. If there is a variation of more than 5 or 10 per cent. between the voltmeter readings, there need be no doubt but that the coil showing the low reading is short-circuited.

949. *How may a short-circuited coil be remedied?*

If the trouble lies at the terminals of the coil it is usually easy to bend or insulate them without removing the coil from the pole piece; otherwise, it should be taken off and rewound.

950. *What are the causes for high temperature in the pole pieces?*

Either heat conveyed to them from other parts of the machine which have reached a high temperature or eddy currents in the pole pieces.

951. *Describe how eddy currents are developed.*

Changes in the magnetic condition of the pole pieces due to a variation in the field current through the magnet coil are responsible for the development of eddy currents. The eddy currents travel at right angles to the lines of force of the field. They penetrate into the interior of the pole pieces, although not to a great depth, and heat the iron cores.

952. *What harm is done if the pole pieces reach a high temperature?*

They raise the temperature of the field coils and so increase their resistance.

953. *How is it possible to tell whether hot field coils are caused by eddy currents in the pole pieces or by too large a field current?*

If eddy currents are causing the trouble, the temperature of the pole pieces will be higher than that of the field coils. A comparison of the respective temperatures of pole pieces and field coils may approximately be obtained by the sense of feeling, if due allowance is made for the difference in conductivity between the iron of the former and the insulation of the latter. A more accurate comparison of temperatures can, of course, be made by means of thermometers properly applied.

954. *What can be done to eliminate eddy currents from the pole pieces?*

The reconstruction of the pole pieces is the only practical remedy. They should be laminated by building them up of plates or disks stamped from soft sheet iron, instead of forming each core of one solid mass of iron. The plates are enameled or painted on both sides, and when dry are bolted tightly together and cast in with the frame. The enamel on the plates acts as a resistance to the eddy currents and checks their formation. It does not, however, impede the flow of the lines of magnetic force through the pole pieces, because these lines pass lengthwise along the plane of the plates.

955. *Are eddy currents ever responsible for unduly raising the temperature of the armature?*

Yes, especially when they form in the armature core. In this case there is no noticeable sparking, but there is a higher temperature in the core than in the surrounding coils. The machine also requires more than the usual amount of current to run it at no load. As in the similar case with the pole pieces relief can be obtained only by laminating the iron core.

If the motor is of large capacity, carrying heavy armature conductors, eddy currents may also develop in them. This trouble may be distinguished from that just mentioned by a higher temperature in the conductors than in the core. It will be necessary to subdivide the conductors into strands or strips, twist them about each other, and sink them into slots in the armature core in order to overcome the difficulty.

More Water Needed at Colliersville

By Thomas Wilson

That a water-power plant should be designed, erected and be in actual operation for some time before it was discovered that there was not sufficient water to run it the year round even to the capacity of the smallest unit installed, would appear to be incredible. Such a plant was designed, however, and put into commission about a year ago on the Susquehanna river near Colliersville, Oswego county, N. Y. This plant was intended to furnish power for the 65-mile line of the Oneonta and Mohawk Valley railroad; also power and lighting to the adjacent towns and villages. The railroad company also has a steam plant at Hartwick, N. Y., about 18 miles distant, from which current was formerly supplied. It is now the intention to use it as an auxiliary to supply any deficiency in current from the water plant at Colliersville. From all indications it would appear that the steam plant must be called into service quite frequently, and during the dry summer months be depended upon entirely.

The equipment is divided into two units of 1000-kilowatt Westinghouse generators direct-connected to Holyoke horizontal turbines of 1600 horsepower each. The Stevens-Hewett Engineering Company, of New York, designed the plant, and in June, 1906, construction was begun by the designers acting as contractors on a percentage basis. Before the work had progressed very far, it became evident that the cost would overrun the estimates. A new contract was consequently executed by the same parties and the firm of William Barclay Parsons was appointed by the owners, Henry W. Bean and associates, as engineers to supervise the completion of the work and the testing of the machinery. The work was completed under the direction of P. S. Tainter, representing the Stevens-Hewett Engineering Company, and tests were conducted by H. M. Brinckerhoff, mechanical and electrical associate of William Barclay Parsons.

From all available information it would appear that the capacity of the plant and the subdivision into units was based on the average minimum rather than the lowest flow of water, and that the data for this flow was taken from inaccurate reports of the Geological Survey and from observations of the designing engineers which extended over a period of only two years' duration. That these observations did not extend over a long enough period even to check the accuracy of the figures obtained by the Geological Survey was evidenced last summer during the worst drought of many seasons. Ordinarily the average low flow of the Susquehanna river at this point is approximately 400 cubic feet per second, but during the dry months of August and September of last year the flow dropped to 90 cubic feet. As a consequence the plant was entirely shut down during these months. During a normal summer it would be possible to obtain from 250 to 500 horsepower during the two dry months for at least a few hours per day. With 1000-kilowatt units this power could not be utilized with efficiency, so that the installation really resolves itself into a 10-month plant averaging from 500 to 3000 horsepower, the latter power being readily obtained from the maximum flow, which is about 6000 cubic feet per second.

For the average power during a year's operation data are wanting, but it is perfectly evident that the plant lacks flexibility. With its unwieldy units it is impossible to take full advantage of the low flow, and just why some smaller units, such as one 500-kilowatt wheel and perhaps two rated at 250 kilowatts, were not installed in preference to one of the 1000-kilowatt machines is a question that should be answered by the designing engineers.

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Is Water Power Cheaper than Steam?

The answer to such a question depends largely upon the size of the plant in relation to the minimum flow, its flexibility, or the power to utilize efficiently all available flow, and the nature of the load to be carried. In many instances the capacity of a plant is based upon the normal June flow, which is considered a fair average, although it is known that the amount of water available during the three dry months following will be away below this figure, and sometimes, if the flow is based on erroneous figures, or if there is an unusual drought similar to that experienced last summer, the supply of water will dwindle to such an extent that it may be necessary to shut the plant down entirely. This condition was realized at the Colliersville, N. Y., plant, as told elsewhere in this number, there being no small units to take advantage of the small supply actually available—nothing but two 1000-kilowatt machines to utilize a flow hardly sufficient to develop 250 horsepower. Fortunately, a steam plant was available to carry the load, and from all appearances it should have been allowed to carry it the year round. Of course, the extraordinarily low water of the last dry season was altogether unusual, and many other water-power installations had their troubles, but with a plant so unwieldy as that at Colliersville, a repetition of last summer's difficulties is almost sure to occur during the dry seasons of succeeding years. Imagine the economy of maintaining two plants to supply a given power: one a water plant operating ten months in the year, and then not always at full capacity; the other a steam plant kept in constant repair and readiness to supply any deficiency in current from the water power. The fixed charges on such an arrangement would be very considerable, and the aggregate cost per unit of output from the combination would in all probability be more than that from an average steam plant designed for the load.

Basing the capacity of a water plant on the minimum flow also has its objections, for during nine months in the year a large amount of water would be overflowing the dam, and there would be enough water available to develop power far in excess of the rating of the plant. Much depends on the nature of the load. A lighting load adjusts itself to some extent with the seasons, that is, it is lighter during the three dry months and heavier during the remainder of the year, when there is usually plenty of water. A motor load requires a constant supply of current with but little variation from month to month, and in such a case it is either necessary to rate the plant on the minimum flow and provide a reservoir for storage, or depend upon costly steam reserves to supply the deficit of power. In either case it is important to know accurately the real minimum as well as the average minimum flow, and no chances should be taken or guesses made as to the actual quantity of water that will be available after the plant is installed.

The Flywheel as an Element of Danger

Seven years of experience of the Fidelity and Casualty Company has shown that the loss ratio in flywheel insurance is twice as great as in boiler insurance; that is to say, the proportion of the money received as premiums to that paid out for losses is twice as great in the case of flywheels as in the case of boilers. For the year just passed it has been three times as great. Another statement warranted by the experience of the same company is that about thirty per cent. more of the flywheels in use explode than of the boilers in use.

In the regulation of speed fluctuation, the capacity of a flywheel depends upon its weight and the speed at which it is run. In a wheel of any diameter, if the speed of rotation be doubled, only one-half the weight is required, and as the cost of flywheels depends directly upon their weight, it is customary, in order to save cost, to make them as light as possible and to run them at the highest possible speed consistent with safety.

The forces tending to rupture a flywheel are in many respects similar to those which tend to bring about boiler explosions. In the boiler the steam pressure exerts a radial force on the shell tending to tear the sheet along longitudinal lines, and when this force exceeds the strength of the material of which the shell is made an explosion takes place. In the flywheel, also, the force tending to tear it apart is radial and dependent upon the speed. In the boiler the force increases directly with the pressure, while in the flywheel the force to be reckoned with increases as the square of the speed. Doubling the boiler pressure simply doubles the stress on the seam, while doubling the speed of the wheel quadruples the force acting on the rim.

In the boiler the strength may be increased by thicker sheets. If the thickness of the sheets be doubled, the boiler is twice as strong as before, but doubling the thickness of the rim of the flywheel, although it doubles its strength, also doubles its weight and the force tending to rupture it, for as the weight is increased so is the centrifugal force, and the rim is no stronger than before, however much it may appear to be so.

The point that is desired to be brought out is this: The flywheel is certainly an element of danger in power-plant operation, if placed in the hands of ignorant

or incompetent men, and it is just as important that the engineer should be as familiar with formulas relating to centrifugal force as with those bearing upon the efficiency of riveted joints.

Draft and Boiler Capacity

Not many years ago an evaporation of two pounds of water per square foot of heating surface was considered good practice. This has been increased to two and one-half pounds for horizontal tubular, and in the case of the water-tube boiler to three pounds for the normal rating. Modern tendencies are to greatly increase this evaporation by burning more coal per square foot of grate area and necessarily increasing the supply of air, which in some cases has practically doubled the capacity of the boiler with but a slight drop in the efficiency. It is now proposed by the Technologic Branch of the United States Geological Survey to double or treble the capacity of a boiler by passing two or three times the usual quantity of air through the fuel bed and boiler. Numerous experiments along this line have been made by passing measured weights of air through two beds of lead shot, one always remaining the same to represent the boiler, while the other is varied as to size of shot and depth to represent the fuel bed. From the data obtained with the shot numerous charts have been plotted and a number of laws deduced bearing on the relative amounts of power required to force air through fuel beds of various thicknesses, composed of various sizes of coal, and through boilers of various lengths and areas of gas passages.

As a result of these experiments it may be possible to increase the rate of working the boiler-heating surface to three or possibly four times the present value. Such an increase would undoubtedly mean new designs of grate, stoker, furnace and boiler, especially fitted for high rates of working.

No attempt should be made to force more air through existing boilers by running the fans at a much faster rate, as the power consumed for this purpose would increase out of all proportion. New fans and engines must usually be installed, which will supply the greater volume of air at as high or even greater efficiency. Data are now being obtained as to the power required by pressure and exhausting fans to produce the desired pressure and volume of air.

One way of reducing the work required from a fan working under the new conditions is to increase the grate area, thus avoiding a high pressure drop through the fuel and insuring better combustion of the fine particles of coal. The pressure drop through the boiler would be increased materially, creating a high velocity where it is desired.

Further experimentation along this line is to be desired, and especially with hot fuel beds and boilers in actual operation. It is the intention of the Geological Survey to perform such experiments in the near future, and the results of their work, to be published in a bulletin on "Drafts," should be of exceptional interest.

Competent Engineers are Not Mere Machines

When an engineer is intrusted with the care and operation of a steam plant it would seem that if he really is competent his judgment should, to some extent, be relied upon in matters involving the spending of money for supplies and repairs.

This thought was brought to mind by the experience of an engineer who has a particularly alert mind and a fertility in resource rarely equaled.

One of the side walls of a boiler furnace needed renewal. On being informed of the need, the proprietor said:

"Get a mason and the necessary material and do the work, but do not allow the expense to run above ten dollars."

Mason and material were secured and the work started. After the wall had been stripped and the new brickwork started, the engineer said to the mason:

"You know just how much firebrick and clay are worth and you know, too, just what you charge an hour for your time. Now keep track of the time, fireclay and brick and when these items together amount to ten dollars, stop work and come out of the furnace."

With about twenty-five more brick to lay, the mason came out and was sent home. Then the engineer notified the owner that the appropriation had been exhausted and the work was not complete. There was nothing to be done except to send for the mason to return and finish the work.

"Why did you let him go away before the work was done?" asked the employer.

"When I came here," said the engineer, "you told me that you wanted to know where every dollar that was spent on this plant went, and you have set the price on a great many things that you did not know anything at all about, thereby costing yourself a lot of money by not allowing the man you hired for what he knew about engines and boilers to use his knowledge. I have grown to be ashamed of some of the things that you have made me do and have called a halt. If I stay with you, I am going to be the engineer.

"I shall operate the plant as well as I know how and make all the money I can for you, but I will not be handicapped any longer by such petty restrictions as you have heretofore imposed on me. I wish to say what repairs are really necessary and where I shall buy belt lacing and lampwick and how thoroughly repair work on the apparatus under my care shall be done, with due regard for the safe and successful operation of the appliances for which I am responsible."

The owner was somewhat surprised at this, and said so, adding:

"I think I can put myself in your place and see the situation from your point of view. I have always looked upon an engineer as a sort of necessary expense accompanying the engine, and in need of the same supervision as other labor. I see that in this instance, at least, the engineer is a real factor in economical power production, and a factor to be reckoned with. In the future we will try to see what can be accomplished by intelligent coöperation; that is, as nearly as we may be able to arrive at it."

In this instance it was readily accomplished and today the engineer of the plant is the head of the department to which he belongs. He treats the plant as though it belonged personally to himself and he is determined that it shall be the best of its kind. He insisted that he be given an opportunity to prove his worth, and when given it he "made good."

Polytechnic Institute Student Section of the A. S. M. E.

This organization has just been formed as an adjunct to the department of mechanical engineering of the Polytechnic Institute of Brooklyn, in charge of Prof. William D. Ennis. The section is intended mainly for the undergraduates, but the movement is being enthusiastically supported by the alumni and other prominent engineers of Brooklyn, many of whom have authorized the committee on admissions to present their names for membership. At present about 65 are enrolled and it was expected that fully a hundred would be on hand for the February meeting.

The activities of the section will take the shape of addresses by men eminent in the various branches of mechanical engineering, visits of inspection to nearby establishments and the reading and discussion of members' papers.

Regular meetings will be held on the first Saturday of each month during the college year, excepting October; usually in the evening, in the auditorium of the College of Engineering, Livingston and Court streets, adjacent to the Brooklyn City Hall.

An improved apparatus for the design of slide-valve gears was recently demonstrated at the Royal Scottish Society of Arts in which a baseboard with two eccentrics mounted upon a crank shaft at one end is used. The shaft is so arranged that the eccentrics and angles of advance may be varied and accurately measured.

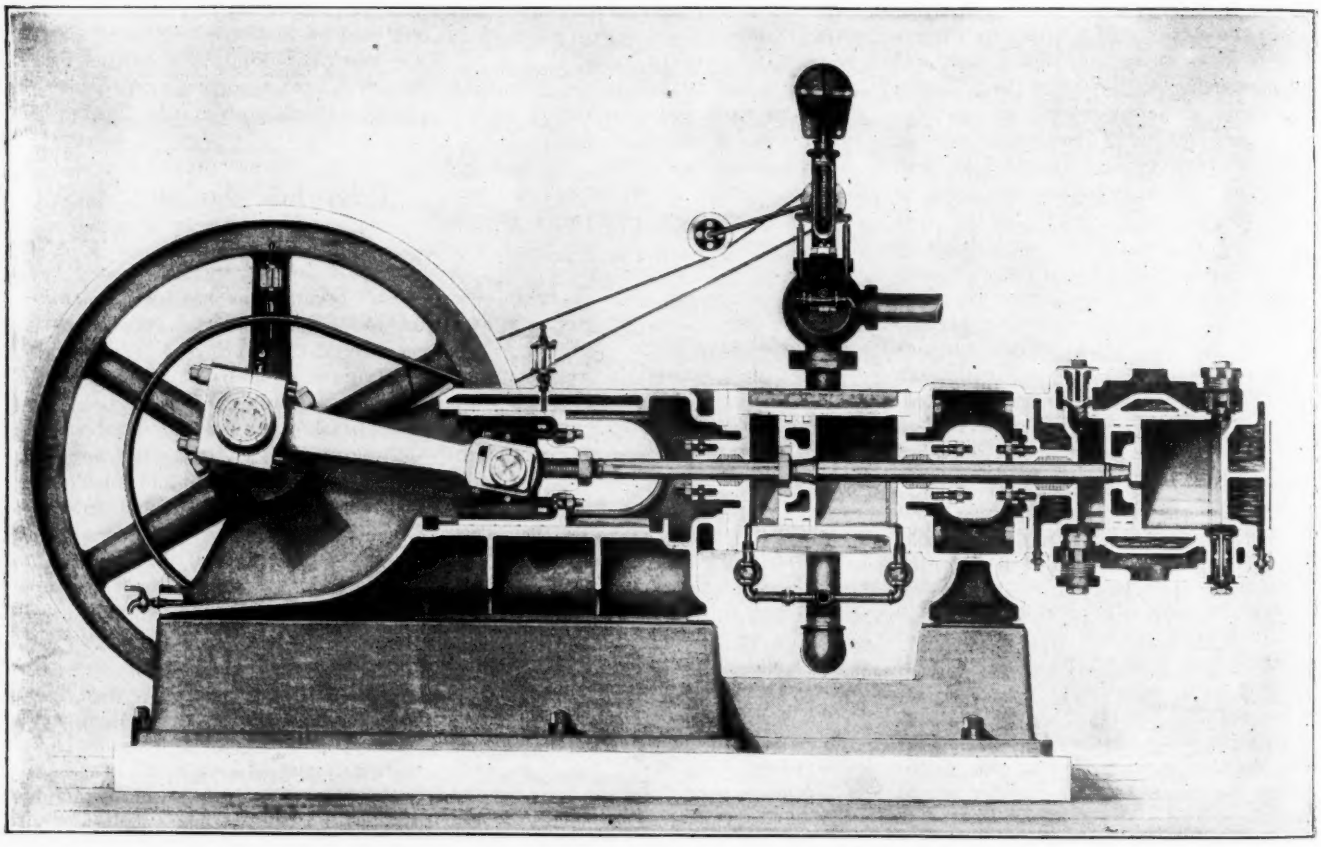
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Dallett Air Compressor

The air compressor shown in sectional view herewith is built by the Thomas H. Dallett Company, York and Twenty-third streets, Philadelphia, Penn. This compressor incorporates the essential features of having all parts requiring adjustment or renewals readily accessible, and employing a liberal amount of metal, so placed as to insure rigidity in operation.



SECTIONAL VIEW OF THE DALLETT STEAM-DRIVEN AIR COMPRESSOR

The frame is of the open-fork center-crank type, designed to obtain on each size of compressor a greater range of capacity by substituting, when desired, a cylinder of the next larger size than the standard to operate at 100 pounds pressure.

The main bearings are lined with babbitt metal, which is thoroughly peened in to obviate shrinkage, and then bored and scraped to fit the crankshaft. The duplex-belt, duplex-steam and single-steam machines are supported on deep, rigid sub-bases, thus making the entire machine self-contained.

The steam cylinder and valve gear of the steam-driven machines are designed to give high efficiency. All steam ports are short and direct, and the clearance has been reduced to a minimum. A plain D balanced slide valve is used on the small and medium-sized machines and the Meyer balanced adjustable cutoff valve on the larger machines. To provide efficient heat insulation, all steam cylinders are lagged with mineral wool and jacketed with sheet steel.

The governor of the steam-driven machine is equipped with a safety-stop device. The governor pulley is situated on the end of the shaft outside of the flywheel on the single-steam machine, thus bringing the flywheel as close to the bearing as possible. Formerly, in the case of duplex compressors with compound steam cylinders, if the machine stopped with the high-pressure side on the dead center, it would not start automatically, due to the fact that the high-pressure side takes steam from the line. This trouble has been overcome by using a reducing valve which reduces the live-steam pressure for use in the low-pressure cylinder. The air and steam cylinders are tied together and held in position by means of an internally flanged tie or distance piece.

Mechanically operated inlet valves are supplied on any size of compressor if desired. These valves are ground to gage and the valve holes lapped to size.

The air-intake and discharge valves are special features of these compressors. The intake valve is of the automatic poppet type, contained in a malleable-iron cage. The cage is one piece, and combines both seat for the valve and guide for the valve stem. The cage is threaded and screws into the wall of the air-intake chamber only, and is simply seated in a recess on the main cylinder wall, using thin corrugated-copper gaskets to secure a tight joint. A hexagonal recess has been cast in all cages to accommodate a special

cast-steel wrench for use in removing and replacing valve cages.

The valve-cage cap acts as a locknut for holding the cage in place after it has been screwed down on its seat in the cylinder. It is provided with a hexagonal projection, and the same wrench can be used here as on the valve cage. In the case of compound machines corrugated-copper gaskets are placed under the valve-cage caps on the high-pressure cylinder to insure against leakage, as the discharge pressure from the low-pressure cylinder is constantly at these joints.

The valve proper is of a special-alloy hardened steel, with seat and stem ground to gage. The valve spring is of phosphor bronze and of the right proportion to give the valve an easy opening and a quick closure.

The spring holder on the valve comprises a split taper ring set in a recess on the valve stem and held tight to the stem by means of a solid taper ring slipping down over it. The hammering of the valve on its seat tends to tighten the spring holder on the stem instead of driving it off, due to the action of the taper.

The discharge valve is of the automatic poppet type contained in a valve cage of malleable iron. The method of seating in the cylinder and locking in its seat is identical with that of the intake valve. A projection or boss has been provided on the valve cap which acts as a positive stop for the valve when it has reached a lift giving a full-opening area and does away with fluttering. This same projection on the cap also acts as a spring guide for the valve spring.

Both inlet and discharge valves are simple and compact, and each valve requires not over a minute's time for complete removal.

The intercooler has a large cooling area, employing the return-flow type of water circulation, and using baffle plates to deflect the flow of air and aid in its effectual contact with the cooling tubes, which may be removed intact from the intercooler box without disturbing any of the piping, as unions are supplied to obviate this feature. The intercooler is supplied with a pop safety valve, a pressure gage and a drain valve.

Each belt-driven machine is provided with an unloading device which automatically unloads the air cylinder. When a certain determined pressure is reached in the air receiver, one or more inlet valves at both ends of the air cylinder are held open and the load is taken off the compressor, allowing it to run light until the pressure drops in the receiver, upon which the valves are released and air compression is resumed.

On the steam machines, a combined speed and pressure governor is used. This governor unloads the air cylinder exactly as on a belt-driven machine, and at the same time it controls the speed, allowing a single-steam machine to turn just over when unloaded, and bringing a duplex or compound machine to a dead stop. By this means a great saving in steam is effected and the wear and tear on the working parts, as in the case of continuous running machines, is reduced.

These compressors are built from 8-inch stroke up to and including 16-inch stroke and with a capacity range of from 79 cubic feet of free air per minute to 1200 cubic feet.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Refrigeration Troubles

I wish to make a few changes in the 10-ton ice plant (can system) I run and would like to have your advice about it. The engine is an old-style compound with 12x16-inch cylinders running at from 90 to 100 revolutions per minute and exhausting into a condenser with a relief valve set at 15 pounds. When we are running more than half the exhaust blows out at the relief. The circulating water for the condenser is the overflow from the ammonia condenser flowing through by gravity. Now what I wish to do is to take the old piston out of the engine and get a new one, throw the old condenser away and put in a surface condenser, and put an oil filter between the condenser and the reboiler.

I think we can cut the coal bill enough to pay for making the changes in one season. The boiler is a horizontal tubular, 66 inches in diameter by 18 feet long, with 48 four-inch tubes, carrying 95 pounds pressure. We burn from 100 to 125 tons of coal a month. I think we burn too much coal for the amount of ice we make and the only way to cut expenses is to cut down the amount of steam the engine uses. And another thing, when we are running we cannot blow the whistle or let the safety valve blow for fear of knocking the cylinder head out. The main steam pipe and safety valve are connected to the highest point on the boiler. The engine lifts the water so you cannot tell how much you have in the boiler. If you are running with two gages in the glass and shut down, nine times out of ten the water will disappear from the glass. Please let me know what you think about it.

W. R. J.

From your description of the conditions existing in your plant we think that your equipment must be suffering from a complication of diseases.

We assume in consideration of what you say that the whole of the 100 to 125 tons of coal consumed per month is burned for generating steam for the ice plant only. If so, it is too much. A 10-ton plant producing 300 tons of ice per month should certainly not require over 75 tons of good coal at the outside and not over 100 tons of poor coal.

If you have steam blowing away through the back-pressure valve it certainly indicates that more water is being evaporated than is required for the ice plant, but safety and back-pressure valves are very deceptive pieces of mechanism, however, and it is almost impossible to gain any idea of the amount of steam escaping by observation alone. Try slowing down your engine until no steam passes the back-pressure valve, keeping the other conditions as nearly constant as possible. This will give you an idea of the amount of steam going to waste, since the total steam will be proportional to the original speed in revolutions per minute and the steam that the condenser will look after will be proportional to the number of revolutions per minute made by the machine after slowing down. The difference in speed in revolutions per minute divided by the original revolutions per minute will give the per cent. decrease in speed which will also be the per cent. of the total steam generated which is being lost through the back-pressure valve.

There would be no advantage in using an engine of so high an efficiency that the steam used would not supply the ice cans with water, and we do not think that it would pay to run a 10-ton plant condensing. If, however, you can improve the efficiency of your steam-consuming apparatus to such a point that it will supply only enough steam to supply the required amount of distilled water without running condensing, it should be done.

We think there is a possibility that your boiler is not evaporating as much water as it should per pound of coal. There must be reasons for your trouble with firemen other than that of the large amount of steam required.

Make sure that the tubes are not getting scaled badly. If this is not the case, we would be inclined to think that there is insufficient draft or insufficient air space through the grates. You should carefully inspect the settings and see that they are as nearly air-tight as they can be made. See that there is no short-circuit which allows the hot gases to pass directly from the combustion chamber to the stack without coming in contact with all of the boiler-heating surface.

It would be interesting to test the strength of your draft by means of a homemade gage rigged up out of two pieces of water glass and a rubber tube. It would also be interesting and instructive to conduct an evaporation test on the boiler. If facilities will not permit of an elaborate test a water meter isolated in the feed line and a set of scales between the coal pile and the boiler will allow you to get a reasonably close determination of the number of pounds of water being evaporated per pound of coal.

Hoboken N. A. S. E. Entertainment

The seventh annual entertainment and reception of Hoboken Association No. 5, N. A. S. E., Hoboken, N. J., took place at Odd Fellows' hall on Tuesday evening, February 9. The attendance was larger than ever before. A top-notch entertainment was given, after which the floor was cleared for dancing, and in spite of the crowded condition of the hall, an enjoyable time was had. The committee of arrangements comprised W. J. Reynolds, James J. Dustin, Adolph Comens, John Platt and Henry Downes.

Newark Association Entertainment

The twenty-fourth annual entertainment and reception of Newark Association No. 3, N. A. S. E., Newark, N. J., was held on Friday evening, February 12, at the New Auditorium. The occasion attracted a large attendance, there being more than 1200 persons present, including many prominent supplymen and engineers. An entertainment of unusual excellence was followed by dancing. The address of welcome was made by A. B. Penny. Great credit is due the hustling committee.

On Saturday evening, February 6, at the Waverly hotel, Lowell, Mass., the Southwick Textile Club of the Lowell Textile School held its eighth annual meeting, at which Charles B. Burleigh gave an address on the equipment of textile mills with electric drives and the use of the steam turbine in connection therewith. The address was one of the best ever delivered before the club and Mr. Burleigh was given a vote of thanks.

Business Items

Orders received during January for "Swartwout" steam specialties made by the Ohio Blower Company, Cleveland, Ohio, include 9 steam separators, 2 oil separators and 10 cast-iron exhaust heads.

The Russell Engine Company, of Massillon, Ohio, is installing a 450-horsepower four-valve semi-Corliss engine for Samuel Bacon's Sons Company, Laurel, Del. Also a 300-horsepower tandem compound four-valve semi-Corliss engine for the Laurel Electric Light and Power Company, Laurel, Del.

A free sample of Ames alloy high-pressure sheet packing is being sent to engineers who apply for it by the U. S. Indestructible Gasket Company, 16 South William street, New York. This packing is made of a special composition and has been tested up to 6000 pounds, making it suitable for the highest pressure and for hydraulic work.

The Hoopeston Gas and Electric Company, Hoopeston, Ill., has placed an order with the Minneapolis Steel and Machinery Company for a 100-horsepower Muenzel producer-gas engine. They already have a 280-horsepower Muenzel producer plant and the small engine will be run on the light loads. In this way they will be able to run the entire plant more economically.

B. M. Knobel, who recently severed his connection with the Crandall Packing Company, has organized the Triumph Engineering and Supply Company, with headquarters at 253 La Salle street, Chicago. Here will be carried a complete line of rubber goods, packings, mats, etc. Also the "Cassco" bar metallic packing. Mr. Knobel has been prominent in steam-engineering circles in Chicago and throughout the middle West.

The G. M. Davis Regulator Company reports a recent shipment to the General Fire Extinguisher Company, of Providence, R. I., of a 30-inch pressure reducing valve to reduce pressure of 75 pounds down to 30 pounds. This valve is designed to pass twenty million gallons of water per day. The shipment weighed three tons and it is considered to be the largest pressure-reducing valve ever constructed in this country. The company also reports the receipt of an order for a 30-inch combination atmospheric relief and back-pressure valve to be used on a 5000-kilowatt Curtis turbine being installed in the 59th street station of the Interborough Rapid Transit Company, New York City. This company has nineteen 30-inch Davis relief valves installed in this plant.

New Equipment

The city of Anadarko, Okla., has voted $14,000 bonds for improvements to electric plant.

H. J. Kunkle, Wataga, Ill., has been granted franchise to construct an electric-light plant.

The Roosevelt (L. I.) Water, Light and Power Company has bought site for a pumping station.

An addition will be built to the power house of the municipal electric-light plant at Nashville, Tenn.

A municipal heating and lighting plant is to be erected in Albion, Neb. R. T. Flotres is city clerk.

The Gloucester (Mass.) Cold Storage and Warehouse Company will erect an additional cold storage warehouse.

The town council, Faundsale, Ala., contemplates installing water-works and electric lights. S. Stollenwerck, town clerk.

It is reported that about $35,000 will be spent in improvements at the water-works and electric-light plant at Opelousas, La.

The Carthage (Tex.) Ice and Electric Company has been incorporated with $20,000 capital by J. C. Whitney, M. E. Pittman and J. G. Woolworth.

The Syracuse (N. Y.) Cold Storage Company will erect a seven-story warehouse, an ice factory and five refrigerating stores at a cost of about $275,000.

The Peoples Ice Company, Wichita Falls, Tex., recently incorporated, will establish ice plant of 45 tons daily capacity. P. Marcus, president.

The Toronto (Ont.) asylum will install four new hot-water boilers, feed-water heaters, pipe, etc. W. D. Medcalf, inspector of boilers, should be addressed.

The Metropolitan Electric Company, Reading, Penn., will erect a new power house and transmission and distribution system at a cost of about $1,500,000.

It is stated that improvements will be made at the water works at Alton, Ill., including the installation of a new pump with a daily capacity of 6,000,000 gallons.

The Ft. Wayne & Wabash Valley Traction Company will remodel its power house at Lafayette, Ind. It is said between $100,000 and $200,000 will be expended.

The Board of Public Service, Cincinnati, Ohio, has been requested to have plans prepared for a new electric-light plant and a refrigerating plant for the city infirmary.

The Great Western Power Company has taken out a permit for the construction of a $50,000 building at Oakland, Cal., to be used as an auxiliary electric generating plant.

The Electric Generating Company, Fredericksburg, Va., has been incorporated with $100,000 capital. Will erect plant. R. M. Vandom, Exchange hotel, Fredericksburg, is engineer in charge.

New Catalogs

Locke Regulator Company, Salem, Mass. Catalog R. Locke engine-stop and speed limit system. Illustrated, 46 pages, 6x9 inches.

Philadelphia Lubricator and Manufacturing Company, The Bourse, Philadelphia, Penn. Pamphlet. The Lubrication of Machinery Bearings. 16 pages, 5¼x8 inches.

Alberger Condenser Company, 95 Liberty street, New York. Catalog No. 11. Wainwright expansion joints, anchors and guides, heaters. Illustrated, 12 pages, 6x9 inches.

D'Olier Engineering Company, 119 South Eleventh street, Philadelphia, Penn. Leaflet No. 10. Steam turbines. Illustrated, 4 pages, 6x9 inches. Bulletin, Series T. No. 9. Horizontal centrifugal pumps. Illustrated, 8 pages, 6½x10 inches.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—A good live agent in every shop or factory in the U. S. to sell one of the best known preparations for removing grease and grime from the hands without injury to the skin. Absolutely guaranteed. An agent can make from $5.00 to $25.00 over and above his regular salary. This is no fake. Write for free sample and agents' terms. The Klenzola Co., Erie, Pa.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

YOUNG MAN wishes position in engine room. Understands steam and electricity thoroughly. Wages no object where there is advancement. Box 5, POWER.

MANAGER, sales manager or traveling by commercial engineer; 20 years' experience, electrical and mechanical lines. M. T. Harwood, 20 Howard Place, Jersey City, N. J.

YOUNG MAN, age 23, four years' experience in the operation of generators, engines, arc lamps, wiring and repair work, wishes position. Good references, reasonable wages. Box 2, POWER.

SITUATION WANTED as oiler or engineer's helper in steam or electric power house, preferably in Pennsylvania or Ohio. Have practical experience and am an I. C. S. student. Box 4, POWER.

SITUATION WANTED by gas engineer, 12 years' experience; can set engines, fit them complete for operation; also line shafting and other machinery. Am 31 years of age and married. Box 295, Carey, Ohio.

POSITION WANTED—Anything in electric plant having water tube boilers, condensing engines, up-to-date equipment, by young man desiring experience. Worked five years in steam plants; Chicago license; Chicago preferred. S. H Viall, 11820 Union Ave., Chicago.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

MACHINERY built to order; up-to-date plant. Write Brunswick Refrigerating Co., New Brunswick, N. J.

PATENTS secured promptly in the United

The Snee Wave Motor and Its Possibilities

A New and Apparently Overestimated Turbine Construction Designed to Utilize the Energy of Ocean Waves and Currents to Develop Power

BY FRANKLIN VAN WINKLE

Windmills and water wheels were undoubtedly the first forms of prime mover devised for the development of inanimate power, and it is not surprising that the restlessness of the seas should have suggested to ambitious inventors the possibilities of developing vast amounts of energy from the motion of the currents and waves of the ocean.

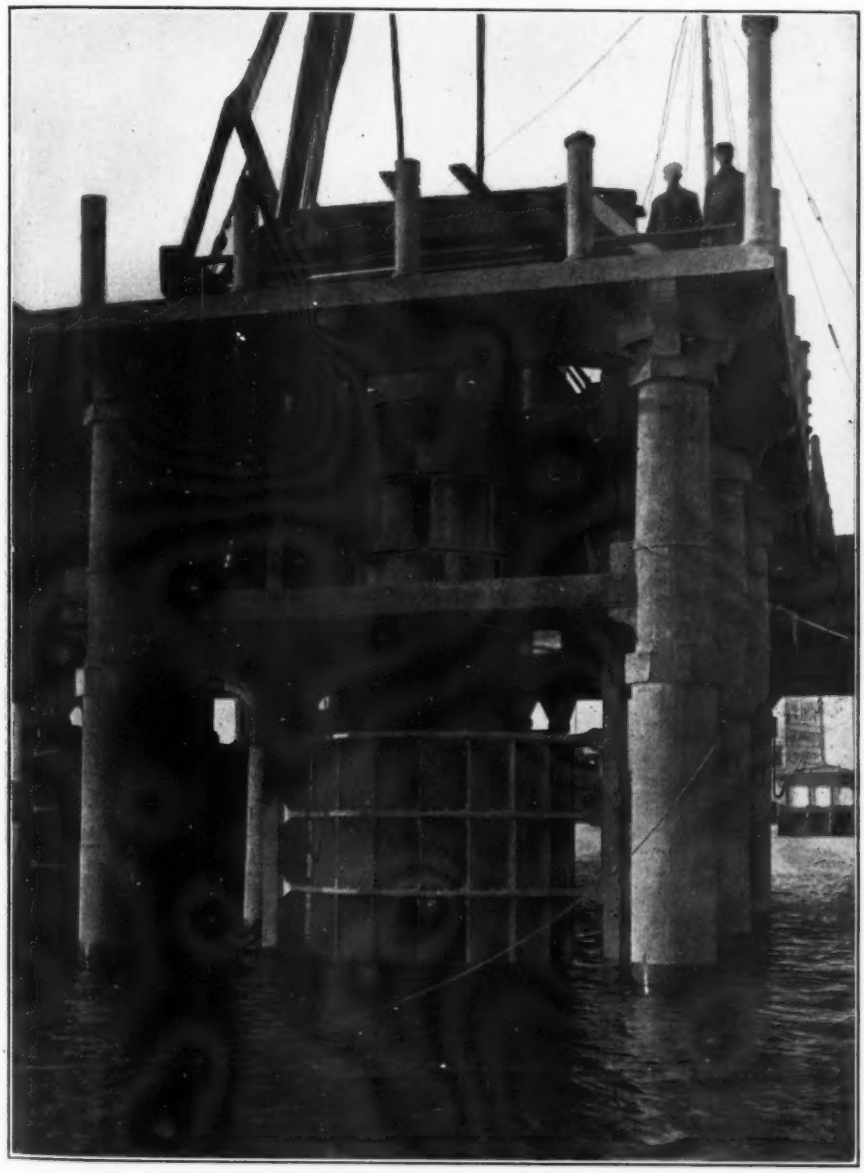


FIG. I. SNEE WAVE MOTOR BEING INSTALLED AT ATLANTIC CITY

The appearance of ocean waves, and the havoc wrought by their incessant action in time of storm give rise to distorted impressions of their motions and local development of energy. When the eye follows the crest of a wave as it moves over the surface of a body of water, the impression is created that the whole body of water is in swift horizontal motion. In reality there is little more than progressive vertical displacement which is almost exclusively confined to a local rising and falling of the general surface. Floating objects, unless driven by action of winds or currents, are carried up and down nearly vertically over the same spot excepting for a small oscillation backward and forward, which occurs as the wave is passing.

The action of surf in breaking over a beach leads many observers to believe that waves consist of an actual flow of the sea shoreward, when in fact the curling and breaking of surf are caused by the final falling down of the unsupported crest of a wave, which in falling and spreading out is rolled over and thrown up as surf by the return of waters from preceding waves that have been spread out on the beach.

Very few of the projects for utilization of wave power have attained importance beyond the experimental stage, because it has soon become apparent to experimenters that, in order to concentrate any considerable amount of energy from power of waves, extensive mechanical installations are necessary, to say nothing of difficulties attending construction and maintenance, and the uncertainty of source of energy and great cost of installation for a given output, as compared with that required for other methods of generating power.

Most of the schemes proposed for utilization of wave power were designed to take advantage of energy created only by the rise and fall of the waves, in which respect they appear to be rational. Some others have been proposed for utilizing the energy of stray currents, oscillations and vertical movements of water, which according to fanciful theorizing are assumed to be inseparable though uncertain accompaniments of wave motion, and very few of the projectors of wave motors of this kind appear from their designs to take into account the fact that in order to gather energy from the movement of water, it is necessary both to arrest the velocity of the water, and for continuous development of energy, the water so employed must be got out of the way of succeeding volumes of water.

A new form of wave motor has been widely advertised of late by the Snee Universal Wave Motor Company in exploiting the sale of $2,000,000 capital stock of

that company. It is claimed for this motor that it will utilize the energy of ocean waves or currents, as well as that of channel and river currents, and "will revolutionize the power development of the world."

Atlantic City Plant

Two wave motors of the company are being installed at Young's new million-dollar pier, Atlantic City, N. J., for the alleged purpose of generating electric current for supplying light, heat and power. As shown in Fig. 1, the plant is being located adjacent to the pier and about 1150 feet seaward from the boardwalk. One of the motors is shown in Fig. 2. It is 14 feet high, 11 feet in diameter over all and weighs 61 tons, the inside revolving section weighing 16½ tons.

From its general appearance the motor might be taken for an elongated turbine. The main working parts of each motor consist of a vertical-shaft water wheel or runner revolving within a circular framework or cage, the latter formed of vertical parallel guide blades, a feature common to all types of inward-flow pressure turbine.

Fig. 3, which is a photograph taken of a small model exhibited at the Snee company's office, 1278 Broadway, New York City, shows the runner or wheel proper, partly removed from the cage or casing of guide blades. In Fig. 2 it will be noticed that the wheels under construction at Atlantic City have their exterior casings supported by two 24-inch I-beams, to which are bolted six steel heads, each 2½ inches in thickness and weighing 4700 pounds. Between these the outside guide blades or deflectors, made of 9/16-inch steel plate, are riveted in tiers, the hight of blade being 30 inches in each tier. The interior revolving part or wheel is to be mounted on a hollow steel shaft and hung from roller bearings, with the bottom of the shaft retained by a compartment filled with oil which is expected to rise in the hollow shaft to a hight sufficient to counterbalance the head of water on the outside. It is proposed to cover the two upright I-beam supports with concrete, and to secure the motors to a foundation resting on nine concrete piles, each containing 1050 barrels of cement and reinforced with steel rails. In addition to this piling, three steel reinforced concrete floors, weighing more than 100 tons each are introduced, making the structure a rigid mass of concrete and steel weighing over 500 tons. Constructed in this manner, it is expected that the action of salt water will not affect the supports of the motors.

Fig. 4, a top view of the motor, shows a brake wheel, by means of which it is expected to shut down on the motor when occasion demands. It is proposed to gear electric generators directly to the shafts of each wheel and operate a storage battery in conjunction with the generating plant, the battery to carry the load between the periods of power supply by the wave motors. It is reported that the exact arrangement and connection of the generators have not been definitely determined.

It is also proposed to install on the top of the foundation wind-driven wheels of the same design as the water wheels and measuring 28 feet in diameter by 50 feet high. This, of course, will increase the cost of the plant, but it is expected that by placing reliance on both wind and wave both motors will not be idle together for any considerable length of time.

fraction of the rating claimed, and would undoubtedly raise the cost of installation per horsepower to such an enormous figure as to limit the use of the motors to their exhibition as novel attractions rather than as efficient and practical machines.

Operation of Motor Analyzed

That a motor of this design, if acted upon by swift currents of air or water, may be capable of developing some power is not to be doubted, for models made of galvanized sheet iron exhibited by the company demonstrate that fact. But the

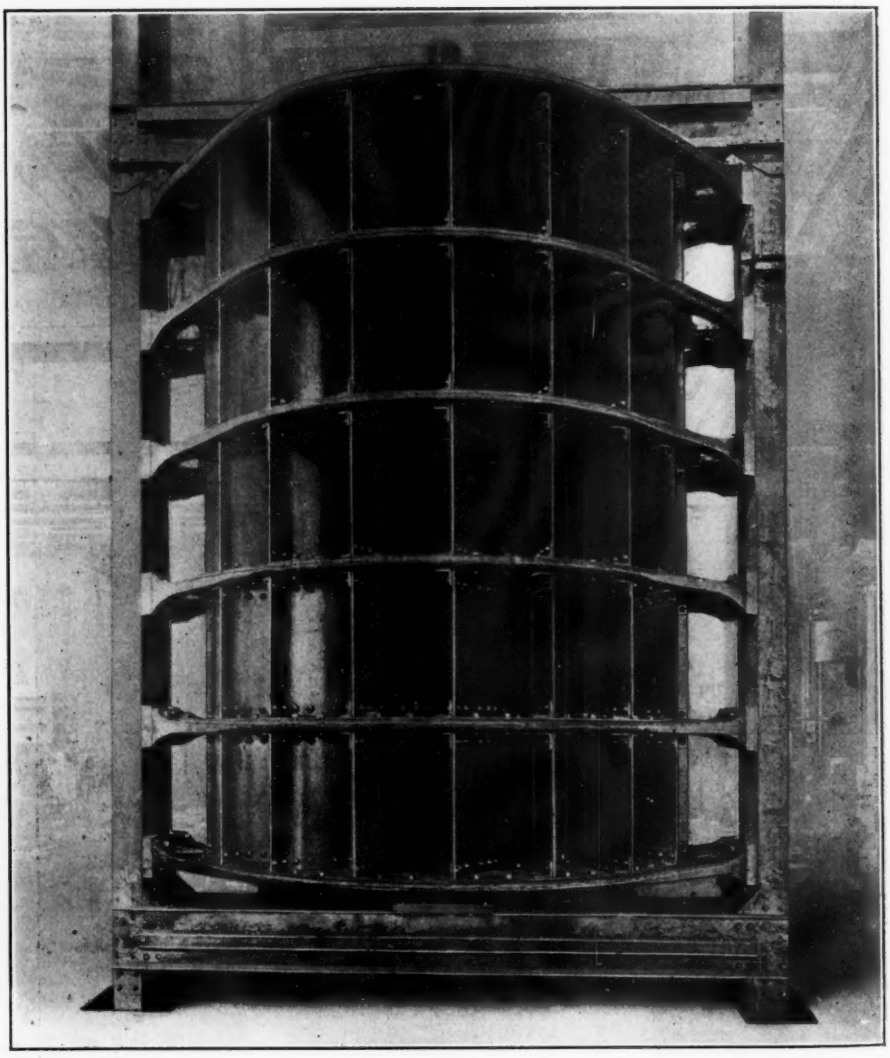


FIG. 2. SUPPORTING STRUCTURE AND ARRANGEMENT OF GUIDE VANES

No very definite data are available on the rating of these motors, only that with a current of 30 miles an hour, or 44 feet per second, each motor is expected to develop 2000 horsepower. The cost of the motors and foundation is placed at $100,000, or when figured at the rating given, $25 per horsepower. An average velocity of ocean waves at Atlantic City of 30 miles an hour is, of course far above normal, and even assuming that the whole body of water partakes of the same velocity as the movement of crests of the waves, the power for usual conditions could be only a small effective energy which motors of a given size and cost may be capable of developing will control their practical usefulness and commercial value. The installation proposed for Atlantic City has been extensively advertised by the projectors and the public is invited to purchase stock of the company upon claims of such extraordinary merit as to elicit an analysis of this wonderful invention.

Fig. 5 illustrates the general arrangement of the guide blades and the runner, shown in horizontal cross-section. In this diagram, A_1, A_2 A_3 A_4 represent the

guide blades, *B* the curved buckets of the runner and *R* the radial vanes of the runner. The radial vanes and curved buckets of the runner are of the same general form as the flat, radial vanes and curved buckets of the ordinary horizontal-shaft water wheels, with the difference, however, that both kinds of float are used

FIG. 3. ARRANGEMENT OF BLADING SHOWN IN SMALL MODEL

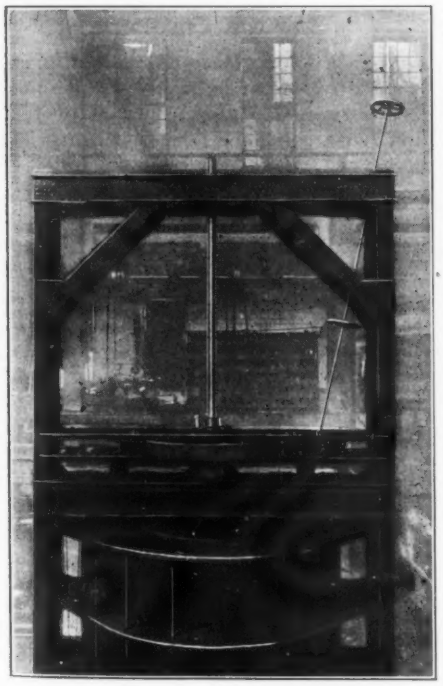


FIG. 4. BRAKE WHEEL ON TOP OF MOTOR

for the runner of the Snee wheel. Flat, radial vanes and semicylindrical buckets in pairs, as shown in the diagram, extend the full depth of the runner with parallel edges devoid of forward or backward curvature. The motor is in fact a current wheel intended to operate successfully with the vanes submerged during complete rotation of the wheel,

A striking feature in operation of the models of this motor is the uniformity of the direction of rotation, regardless of the direction of flow of the propelling current, and it is therefore proposed that this motor will be especially valuable for deriving power from waves and tidal currents as well as from river currents which are constant in direction of flow.

It is to be observed that in operation the Snee motor differs from that of the inward-flow turbine in one important particular, viz., that inward-flow vertical-shaft turbines are constructed for discharging the propelling fluid downward through the runner, while for operating the Snee motor the propelling current must enter through guide passages in one side of the motor, engage the buckets as it passes across the guide case and be discharged through other submerged guide passages on the down-stream side of the motor.

Placed in an open current sweeping across the motor, it would appear, as indicated by the arrow-head flow lines of Fig. 5, that not more than one-fourth of the guide passages can possibly be construed as effective in delivering water to the blades of the runner, because entrance through any more of the guide passages would only result in choking off free admission by those passages which are most effective in discharging water upon the runner. Rotation of the runner being in the direction indicated by the arrow *V*, it is to be noted that when the propelling current approaches the motor from the side *T* the effectiveness of water entering a guide passage like *A* will be seriously interfered with in the transfer of its energy to the vanes and buckets which have arrived at *D*, because there is no outlet for discharge of deflected water except by cutting across the path of other vanes, thereby causing a churning action and a breaking up of the solidity of masses of water which are in the wake of such vanes. The energy required to effect this displacement must be reserved out of the initial energy of current which may be presented to the runner, to say nothing of the effect of the breaking up of the solidity of water between vanes which have passed around to positions beyond useful effect from jets or streams impinged upon the runner.

The churning action referred to is somewhat lessened by the backward curvature of the outer ends of the series of curved buckets, but this feature cannot possibly compensate for energy lost in the formation of swirls and eddies between the vanes. While it may be said that energy rejected by the first vane or bucket will thus be gathered by vanes on the opposite side, it is readily seen that a very large portion of such residual energy is not thus available for that purpose, and besides, as any energy which may be so available is to be derived only from irregular streams of water flowing at irregular velocities, the gathering of this residual energy is extremely incompatible with a well established principle of turbine water-wheel practice, viz., that in order to realize the best effect, either by impingement or pressure on a vane, there must be a fixed ratio between the velocity of the water and that of the vane. Analysis of this motor under principles of turbine water-wheel practice would, there-

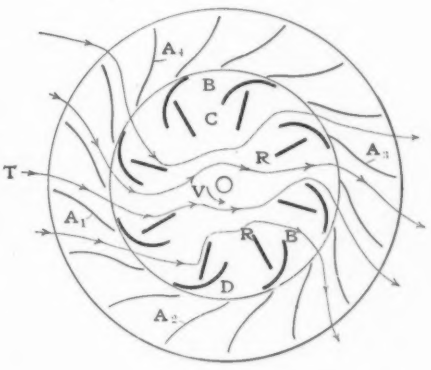


FIG. 5. INSTANTANEOUS FLOW IN SNEE MOTOR

fore, appear to be entirely out of place.

Assuming the course of the current across the wheel to be constant in direction and velocity, the effective energy transmissible to the vanes and buckets of the runner cannot be construed as equal to the energy derivable from direct action of the main current, because there is counter action of deflected currents. The efficiency of vanes receiving direct and uninterrupted action of currents has been clearly established by Smeaton and other experimenters, and more particularly by Poncelet in testing the efficiency of ordinary current wheels.

In nearly all countries, and for many centuries, crude float wheels, with horizontal axes and driven directly by swift currents of rivers or tides, have been in use for raising water and for other mechanical purposes. Water wheels of this kind were undoubtedly the earliest form of rotary hydraulic motors, see Figs. 6 and 7. Carried on boats moored in a rapid current, they have been quite ex-

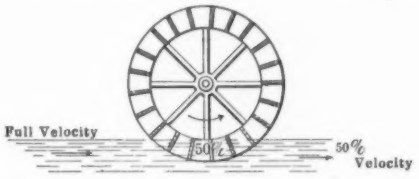


FIG. 6. VERTICAL SECTION OF CRUDE CURRENT WHEEL

tensively used in European countries to develop power for small floating grist mills.

These water wheels are usually provided with flat radial vanes or floats placed around the periphery of the wheel like those of an ordinary steamboat paddle wheel, the floats or paddles being spaced apart a distance equal to their radial

length, which is usually about one-fourth the greatest radius of the wheel.

It has been demonstrated that for the best effect from these wheels, only so much of the wheel should be lowered down into the water as to insure complete submergence of each float as it passes under the axis of rotation of the wheel. The vanes dip into the unconfined current and receive motion from the passing water, accompanied by a heading-up of the impeded current. Much of the main body of the current passes to either side of the wheel, and in order to receive any energy from that portion of the current which does present itself to the floats, the floats must have less velocity than the current. These wheels cannot, therefore, be made to utilize more than a small proportion of the total energy of a current, and Poncelet found that they could develop only 40 per cent. of the energy of that portion of the current which had cross-sectional area equal to the projected area of one vane.

The maximum energy that can be imparted by a jet to a flat vane, normal to an unimpeded jet or stream of water which is free to glide from the vane, is one-half of the energy of the jet. But in operation of current wheels, such portion of volume of the jet or stream acting on the vanes as may be in excess of the quantity which can follow the vane in its path is impeded in its escape by a surrounding body of water which offers more resistance than if the excess discharged itself into the atmosphere.

Where any considerable amount of power is required, the employment of water wheels of this kind is usually prohibitive on account of the extensiveness of installation necessary for a given capacity, and also their great cost as compared with installation of other forms of prime mover.

The old horizontal float wheels possess the advantage over the Snee motor of retaining the dead water between the floats undisturbed by discharge from the surface of the vanes, and it would therefore seem physically impossible for the Snee motor to realize equal benefit from a given amount of energy of current from the time of its induction upon the runner to the time of its exit from the guide case, even though the directions of discharge chanced in all instances to be favorable to forward propulsion of the runner.

In the Snee motor retarding resistance will be offered by sweeping water between the vanes around the side *C*, Fig. 5, whether the water is thus carried as dead water or is made up of water deflected from vanes, and the proportion of back-water effect thus introduced will be considerably in excess of the proportion of total energy wasted in back-water effect by the old horizontal wheels with flat radial floats, as back-water resistance in the latter is only such as may be due to lifting the vanes gradually out of dead water moving with nearly the same direction and velocity.

The backward curvature of the curved buckets and "ventilation" afforded by the arrangement of curved buckets, as combined in pairs with radial vanes, have the effect of attracting outflow to the side *C*. Though the direction of such outflow may

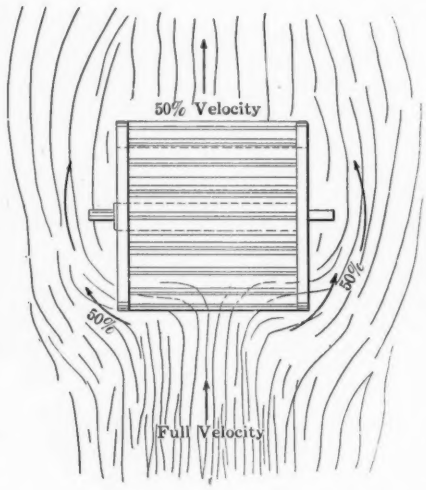


FIG. 7. PLAN OF CRUDE CURRENT WHEEL

chance to be favorable to the direction of rotation of the runner, there must be a sweeping around of dead water immediately in advance of the vanes on the side *C* with the final presentation of a solid body of water to all guide passages at which admission occurs. Neglecting any centrifugal tendency, and assuming that the dead water describes a circular path with half the velocity of current striving for entrance from tangential guide passages, the current cannot enter the space occupied by the runner without being checked in its velocity by the presence of dead water accompanied by a heading up of current which will fall to waste in passing to both sides of the motor. Any water which may enter and pass across the inner compartment has its velocity further reduced by the presence of dead

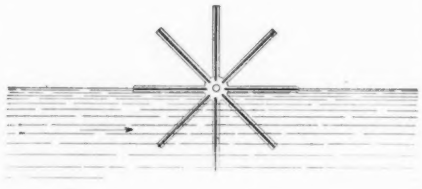


FIG. 8. RADIAL-VANE CURRENT WHEEL SUBMERGED FULL DEPTH

water and is constantly hindered in transfer of energy to the vanes or buckets of the runner by interception of dead water in its course and is halted in its velocity by the increasing presence of dead water. Whether or not it is so intercepted by all the dead water, a considerable amount of the energy so developed under such conditions is absorbed in sweeping dead water around the interior of the guide case.

It would therefore appear that the motor would operate more efficiently if turned on its side, with the axis of rotation horizontal, and were to be charged only with energy of current having a cross-sectional area equal to the projected area of a vane.

The tangential arrangement of guide blades can be considered of advantage only in better directing the current on the vanes of the runner. Their employment results, if anything, in a waste of initial energy of current by changing its direction. The greatest advantage that can be claimed for them is that the gradual reduction of the guide passages results in the reduction of waste of head incidental to changing the direction of current tangential to the path described by the vanes. However, no more energy is recoverable than the tangential deflection is responsible for, and it is extremely doubtful whether the presence of rivet heads and other sources of roughness of the surface of the guide blades can be compensated for in this manner, either when the passages are considered as only mouthpieces for admission of water to the runner or as gradually enlarged ajutages for final discharge of water from the space occupied by the runner.

Probable Efficiency

Whether or not the disadvantages pointed out do attend induction of initial current upon the blades of the runner, the total energy and effectiveness must be materially less than though the wheel were composed only of straight radial vanes extending from the center to the periphery as though the impingement of current were directed upon one-half of the wheel, employed as a horizontal-current wheel, as shown in Fig. 8. In such a case, the energy of current chargeable to the motor would be that portion of the current whose sectional area would be equal to the radius of the wheel, multiplied by its length, and the center of effective pressure would be at the center of the area of the vane. As, for best results, the velocity of the center of the vane should be one-half the velocity of the current, the velocity of the periphery of the runner would have to be equal to the velocity of the current, receiving no energy from the water. The total effective energy would be only one-half as great as though directed on the periphery with appropriate velocity of periphery.

The arrangement of guide passages of the Snee motor can hardly be construed as effecting direct delivery of current on more than one-half the full radial size of the runner wheel, and an estimate of capacity and efficiency based upon that of a current wheel receiving an area of current equal to one-fourth the projected area of the runner wheel and acting on radial

vanes of the same area and in the same manner as in crude float wheels would accord to this motor as high power and efficiency as it is capable of developing, if not higher.

Speed of current, diameter, length and weight of runner, depth of submergence, velocity of runner and form and roughness of guide passages, buckets and vanes will all have material influence on the effectiveness of the wheel, but the assumption of maximum capacity and efficiency as given are based on all of these conditions being in most favorable combination.

Possible Power Development

The motors proposed for installation at Atlantic City have runners about 14 feet long and the diameter of the runners would appear from Fig. 4 to be something under 5 feet. Assuming these dimensions for the runners and the effective current area chargeable to the motors to be one-fourth the projected area of the space occupied by the runner, then the sectional area of initial water current operating on one of these motors would be one-fourth of 70, or 17.5 square feet.

Calling f the gross energy capable of being exerted by a current of water expressed in foot-pounds per second, then

$$f = A\,v \times W \times \frac{v^2}{2g}, \qquad (1)$$

in which

A = Cross-sectional area of current in square feet,

v = Velocity of current in feet per second,

W = 62½ pounds, being the weight of 1 cubic foot of water, and

g = 32.2, the acceleration of gravity.

Substituting these values equation (1) may be written:

$$f = 0.97\,A\,v^3. \qquad (2)$$

From equation (2) it is to be observed that the foot-pounds per second vary directly as the cube of the velocity of current. Substituting for A, equation (2), the quantity 17.5 square feet, the cross-sectional area of effective current assumed for one of the Snee motors gives

$$f = 0.97 \times 17.5 \times v^3 = 16.975\,v^3$$

foot-pounds per second. The gross horsepower of current acting on the motor would be

$$\frac{16.975 \times v^3}{550} = 0.03086 \times v^3$$

gross horsepower in the water.

For reasons which have been pointed out, it would appear impossible for the Snee motor to realize as high per cent. of efficiency as Poncelet found for crude current wheels which, as stated, was found by him to be 40 per cent. The interference and cross-currents encountered by the water in passing through the runner of the Snee motor cannot but detract from the transfer of its energy to the vanes of the runner, and the retarding effect must necessarily place its efficiency below that of the crude current wheels varying with the velocity of the current presented and the speed of rotation of the runner. But for purposes of commercial comparison of this motor with other methods of generating power, if the same percentage of efficiency is accorded to these motors as ordinary current wheels, viz., 40 per cent., then the net horsepower of one of these motors would be:

$$0.40 \times 0.03086 \times v^3 = 0.01234 \times v^3.$$

One of the principal claims for these motors is that they have usefulness in developing power from ocean waves. This must be on the assumption that wave motion is accompanied by horizontal flow, i.e., current sweeping through the motor. Should a wave dash upon and spill over the motor it could only result in spasmodic bursts of energy, only momentary in effect and so weak as to be worthless of storage from the time of one wave to another. The horizontal velocity of current incident to wave motion is practically nothing, except in the case of surf waves, and then there is velocity only by the wave falling down and spreading out. If a place can be found for setting up one of these motors where surf waves fall down at all stages of the tides, then the current or spilling-over action of surf waves might be availed of. When it is considered that two surf waves rarely break in the same spot, the impracticability of dependence upon the action of surf waves can be understood.

It is a fact, however, that ocean currents exist and that surface currents are augmented by the travel of crests of waves in the same direction, but there are few, if any, ocean currents which ever attain a velocity of 5 miles per hour, and tidal currents of channels and rivers which empty into the ocean rarely attain that velocity. A velocity of 5 miles per hour would be equal to 7.33 feet per second. If such an ocean current could be found for installation of one of these motors, then its development of power, if accorded 40 per cent. efficiency would be:

$$0.01234 \times (7.33)^3 = 4.86\ \textit{horsepower}.$$

The U. S. Coast Survey reports the average flood-tide velocity through Hell Gate channel as 4.7 knots per hour and average ebb tide as 4.8 knots per hour. The average of these, 4.75 knots per hour, would be equal to 8.02 feet per second. This channel is about the swiftest of any waters in the vicinity of New York City. If one of the Snee motors of the size of those being installed at Atlantic City were to be placed in Hell Gate channel, then on the same assumption of 40 per cent. efficiency of current, its power would be:

$$0.01234 \times (8.02)^3 = 6.36\ \textit{horsepower}.$$

The results to be attained by placing these motors on a beach like that at Atlantic City are hard to conjecture, but the power obtainable can scarcely be assumed as equal to that obtainable in the swift channel of Hell Gate, and this amount certainly would not warrant a very serious investment.

Placing the annual value of a horsepower at $40, and regarding this value per horsepower as worthy of capitalization on a basis of 5 per cent., each horsepower might be regarded as worthy of an investment of $800. Taking for granted that the cost of installation per motor would be only $25,000, i.e., only half as much as quoted for the installation of those at Atlantic City, it can be seen that in order to make a paying investment on the assumed basis of horsepower values, the $25,000 motor plant would have to be capable of developing 31¼ horsepower at $800 per horsepower. In order to develop 31¼ horsepower, the motor would have to be employed in a current of sufficient velocity to fulfil the equation

$$0.01234 \times v^3 = 31\tfrac{1}{4}\ \textit{horsepower},$$

i.e., v^3 must equal 2532.414, showing that a velocity of initial current of 13.6 feet per second would be required. This would be in a current having a speed of from 9 to 10 miles per hour.

Even though such an ocean current were to be found the difficulties of installation would undoubtedly increase the cost far beyond the assumed figure, $25,000. There may be a few isolated locations where river currents attain the enormous velocity of 9 to 10 miles per hour, but the difficulties due to choking up the motor from silt and débris would unquestionably make such installation entirely impracticable.

As for the Atlantic City experiment, it will be surprising to learn that it has accomplished anything worthy of establishing interest in the Snee motor beyond exhibitional purposes.

Civil Service Examination

The United States Civil Service Commission announces an examination on March 17 at the usual places to secure eligibles to fill a vacancy in the position of mechanical and electrical engineer, $1200 per annum, Quartermaster's Department at Large, Fort Bayard, N. M., and similar vacancies as they may occur in any branch of the service.

Applicants who have not had at least five years' practical experience in mechanical and electrical engineering will not be admitted to this examination. Graduation in mechanical or electrical engineering will be considered as equivalent to not less than three years of this period. Applicants should at once apply to the United States Civil Service Commission, Washington, D. C., for application form 1312.

Central Heating Plant for Lebanon, Ind.

By Byron T. Gifford

The Central Station Engineering Company, of Chicago, Ill., has just completed a central-station hot-water heating system for the Lebanon Heating Company, of Lebanon, Ind. The system covers the

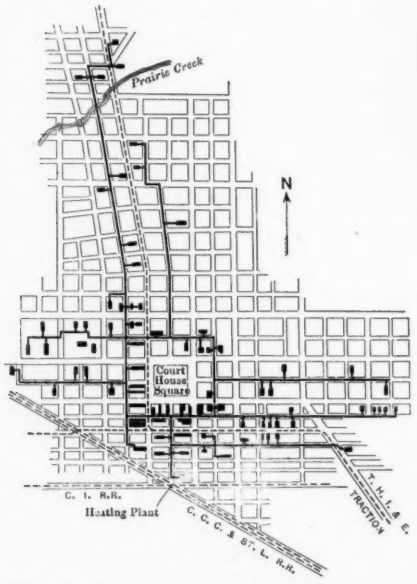


FIG. 2. INITIAL INSTALLATION OF STREET MAINS

best residence district, as well as the business district of the city. Nearly all the mains are located in alleys, which are used wherever practical. In the initial installation, that is, the mains which were laid last year, there are approximately three miles of pipe lines, ranging in size from 12 to 3 inches. The sizes of these mains and laterals were determined by

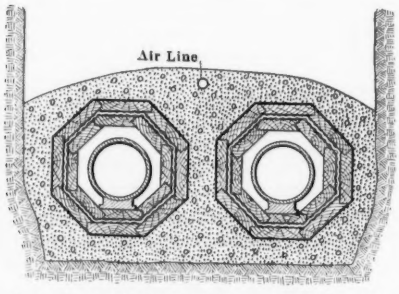


FIG. 3. CROSS-SECTION OF CONDUIT FOR WATER LINE

making a careful survey of the territory to be served, and ample capacity has been reserved for future extensions from the original installation.

The pipe line leaving the station is 12 inches in diameter, and continues that size up to the first alley south of the public square; there the line branches two ways with 8-inch pipe which circles the square in the alleys and ties together on the north side, forming a belt which acts as a center of distribution and equalizes the pressure on the lateral lines. Gate valves are placed on all laterals, and also on both sides of the branches in the belt line, in order that any part of the distributing system may be closed off at any time without interfering with the service on the balance of the system.

The system is arranged on the two-pipe pressure-differential plan, and the pipe sizes are based upon a maximum velocity of 5 feet per second. The amount of water to be handled is determined by the number of square feet of radiation to be served, nine pounds per square foot of radiation per hour being the maximum amount used during the coldest weather. The insulation used around the mains is Wyckoff patent steam-pipe covering, which was put in place after the pipes had been tested and made tight under 80 pounds cold-water pressure. After the covering was in place and the joints thoroughly waterproofed with asphaltum, the entire covering was surrounded with from 2 to 3 inches of concrete of 1-2-5 mixture. This was applied comparatively wet and was thoroughly tamped so as to fill completely all spaces around the

FIG. 1. STATION OF LEBANON HEATING COMPANY

covering. The concrete envelop acts as a physical protection to the covering, as well as a foundation for the pipe line, and is not considered an insulator.

The air line, which is used as a conductor of compressed air for the operation of the temperature-controlling devices placed on each job, is also embedded in the concrete, as shown in Fig. 3. The expansion joints, shown in Fig. 4, are of the slip-joint type with a brass sleeve sliding into a cast-iron body. These joints have extra-large packing boxes and are of the removable-gland pattern to insure easy access to the joint for the purpose of repacking.

The pipe rests on rollers which travel in metal guide plates, placed approximately 6 feet apart. The anchors, used to hold the pipe in place securely and control their expansion and contraction, are of the beaver-tail type, as shown in Fig. 5. These anchors are placed around the pipe at a coupling in the line, and are embedded there in an enlargement of the concrete envelop. Large roomy double-lidded manholes are built around each set of expansion joints and valves, the extra lid serving as a dirt catcher. The entire line is buried at least 3 feet under the surface of the ground. Detail of the entire line, showing all possible conditions between two anchor points, is shown in Fig. 6. Water leaving the heating station at 200 degrees Fahrenheit will reach a consumer 7/8 of a mile away from the station at 197 degrees Fahrenheit.

Boiler Installation

The station is located at a junction of

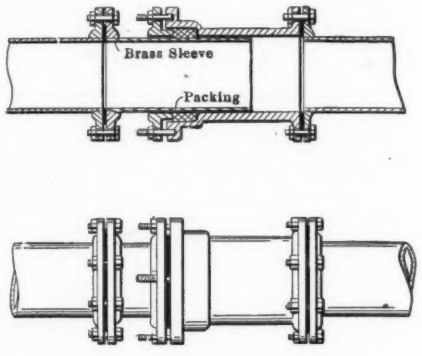


FIG. 4. TYPE OF EXPANSION JOINT IN USE

the Big Four railroad and the Central Indiana railroad, the latter being the direct road from the Indiana coalfields. Coal is unloaded directly in front of the boilers from a side track connecting both of the above-mentioned railroads. The coal goes into a large bin, which is made as nearly dustproof as possible, being lined with paper and built of matched lumber. The boilers in the initial installation are four in number, viz., two 80-horsepower return-tubular boilers, and two 347-horsepower circulating boilers. The steam boilers are used to generate steam for the circulating pumps and other

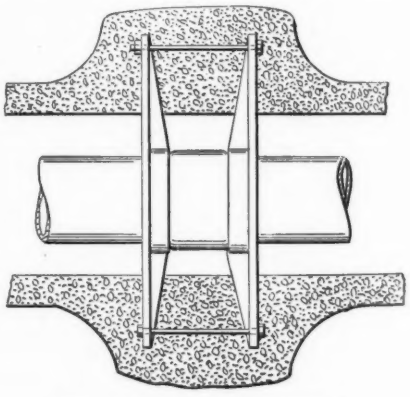


FIG. 5. BEAVER-TAIL ANCHOR

steam-driven apparatus in the station. The circulating boilers, built by the Rust Boiler Company, of Pittsburg, Penn., are composed of three banks of tubes connected to six drums, three at the top and three at the bottom. The circulating water enters the top drum at the rear of the boiler, passing down a bank of tubes to the lower rear drum, then over to the lower middle drum through a row of tubes, rising to the middle drum at the

top and passing over to the front drum at the top, then down to the lower drum at the front and from there into the flow main and out into the pipe line. The gases in these boilers pass from the lower front drum to the upper front, down the middle bank of tubes and up the rear bank. With this arrangement the hottest gases come in contact with the hottest water, and the coldest gases with the coldest water. All four boilers are equipped with Green chain-grate stokers. Mechanical draft is used because of the low temperature of the gases under the circulating boilers, which would have necessitated a very high stack had natural draft been used.

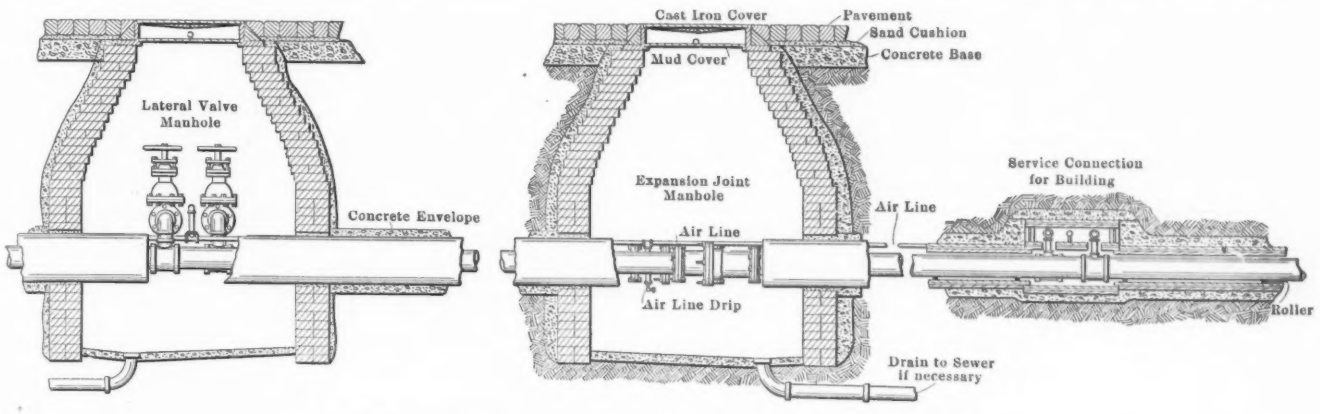


FIG. 6. COMPLETE SECTION OF PIPE LINE BETWEEN ANCHOR POINTS

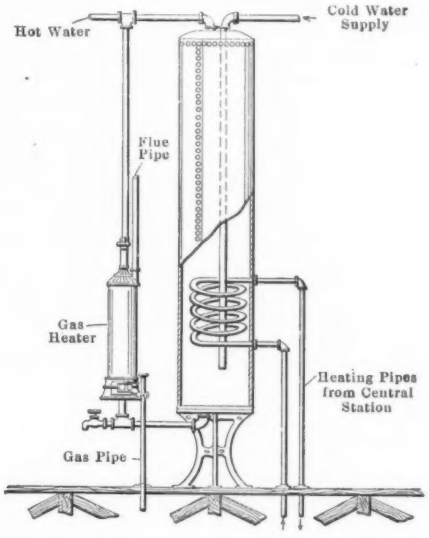


FIG. 7. HEATING WATER FOR DOMESTIC PURPOSES

and other steam apparatus in the station, the condenser being so designed as to pull at least a 1-inch vacuum under all conditions. After the water leaves the condenser it goes to the circulating boilers, and there absorbs the amount of heat necessary to raise the temperature to the schedule then prevailing, before it is again sent around the heating mains. All the necessary auxiliaries, such as boiler-feed pumps, line-pressure pumps, governors for the same, condensation pumps, deep-well pumps, etc., are installed. A gage board equipped with thermometers, gages, etc., shows at all times just what the entire plant is doing.

Pumps and Piping

The return water enters the station, and at its minimum temperature passes through De Laval centrifugal steam-turbine-driven circulating pumps. It then passes through a surface condenser, in which is utilized all of the exhaust steam from the different pumps

At the present time the load connected to the plant is 60,000 square feet of radiation. Of this amount about 10,000 square feet consists of gravity equipment, which was installed in the different buildings before the central plant was built. The balance, or 50,000 square feet, is equipped for central-station heating, with no pipes smaller than 1 inch. The temperature of each building is controlled by a thermostat operated by compressed air supplied from a Westinghouse air compressor at the station. If desired, the company allows circulating water to pass through a coil in a range boiler, as shown in Fig. 7, in which water is heated for bath, lavatory, laundry or kitchen purposes, giving the consumer at all times hot water ranging from 120 to 150 degrees temperature.

Service Lines

The service lines running from the mains to the different buildings are installed in practically the same way as the mains. Where the service leaves the main, a swing joint is put in to take up the contraction and expansion. A curb box with shutoff valves is placed just inside the curb line, or just outside of the property line in each service. The concrete envelop and other features are the same as in the mains. A longitudinal cross-section of this is shown in Fig. 8.

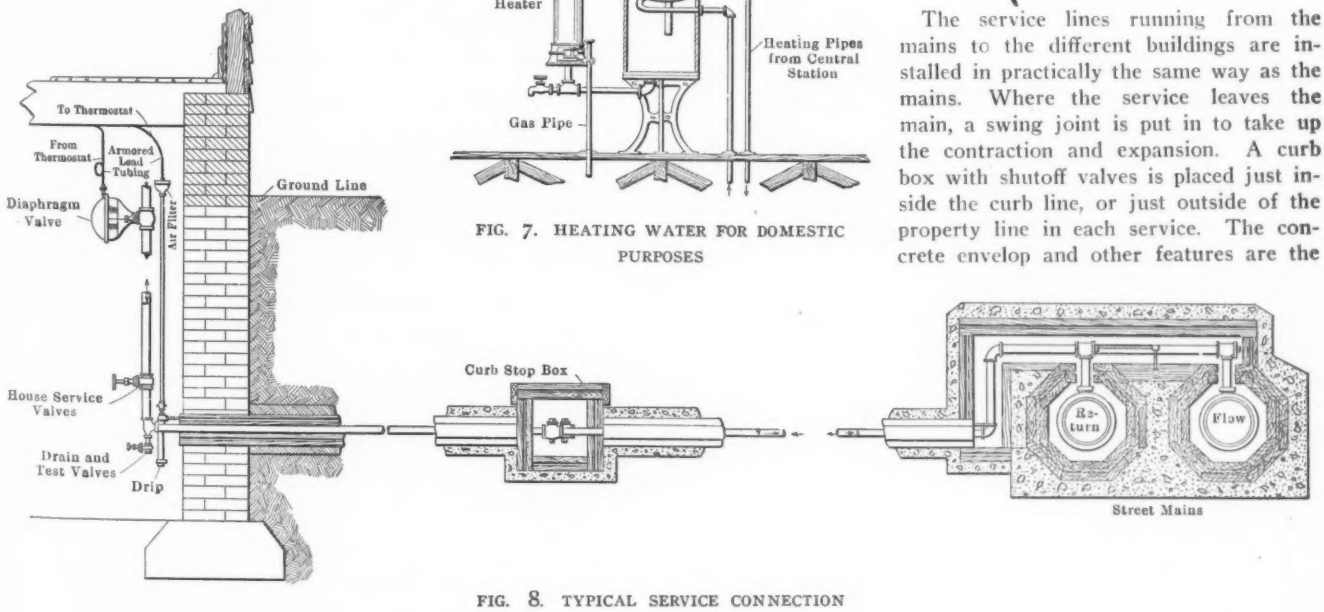


FIG. 8. TYPICAL SERVICE CONNECTION

Duplicate apparatus consisting of pumps, boilers, heaters, etc., have been installed, and space is provided for future installations in order that there may be an ample factor of safety in power-house equipment to insure an uninterrupted service.

Flanged Pipe Joints for High Pressure

Types of Screwed Joint, Peened, Shrunk and Riveted; Variations in the Van Stone or Lap Joint, and the Autogenous Welding of Flanges

BY WILLIAM F. FISCHER

One of the problems confronting the engineer in the installation of a system of high-pressure steam piping for the modern power station is the selection of a flanged pipe joint suitable to the work, pressure carried on the boilers and temperature of the steam if superheated. The failure of a flanged pipe joint, if properly made, is seldom attributed to the steam pressure alone, but can nearly always be traced to other causes such as careless erection, improper support of the piping, valves, fittings, separators, etc., or to the combined stresses caused by expansion, contraction, vibration and water hammer.

Screwed Joints

Although the old-fashioned screwed joint has proved entirely satisfactory in the majority of cases, when used in connection with saturated steam for pressures up to 160 pounds and in many cases even greater with a moderate degree of superheat, it is generally acknowledged, however, that the screwed, shrunk, shrunk and peened, or riveted joints are not altogether suitable for steam mains carrying the high steam pressures of today, or for highly superheated steam, due to the fact that these joints, when strained to any extent, have a tendency to develop a leak through the threads or between the pipe and the flange.

In many cases leakage or failure of a screwed joint when under pressure is due as much to imperfect and careless workmanship in the cutting of the threads and the fitting of the flanges, as to careless erection or poor design of the piping system. It is important that the threads be perfectly cut to standard sizes with tools of the best quality and in good condition. The pipe should be screwed completely through the flange to guard against leakage, and also to make the threads metal-tight against the oxidizing action of leaking steam and water. All grit, dirt, iron chips, etc., should be thoroughly removed from the pipe and flange threads before screwing on the flange, otherwise the friction of the parts may be so great as to prevent the joint being made up steam-tight. Occasionally in the larger sizes the pipe to be threaded is not perfectly round, having been flattened in handling or during transportation, and the threads cut deeper on one side than on the other. In a case of this kind the steam is apt to leak through the threads, no matter how tight the flange.

Several methods have been devised for making screwed joints to guard against leakage through the threads. One method in use is to cut a calking recess in the hub of the flange, as shown at *A* in Fig. 1. The pipe is screwed into the flange steam-tight, and the recess *A* is filled with soft copper which is calked in firmly. All flanges fitted with this recess should be ½ inch higher on the hub than the regular flanges to give sufficient bearing for the threads. The dimensions of the recess, as given in the figure, were furnished by the Crane Company.

Screwed and Peened Joints

Another method is to peen or roll the end of the pipe into a peening recess at the face of the flange, after making the flange up tight on the pipe. Such a joint is shown in Fig. 2. The pipe and flange are carefully threaded, and the pipe is screwed completely through the flange, leaving the end projecting slightly beyond its face. The pipe is then pounded down around its inner circumference with a peening hammer, or is sometimes rolled by special machinery, until the end completely fills the recess *A*, making a steam-tight joint between the pipe and the flange. The pipe is then put into a lathe and the joint faced off true to insure the face of the flange being perpendicular to the axis of the pipe.

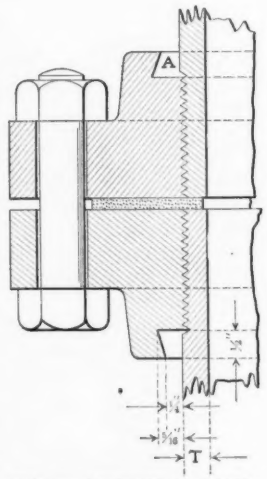


FIG. 1. SCREWED FLANGES WITH CALKING RECESS

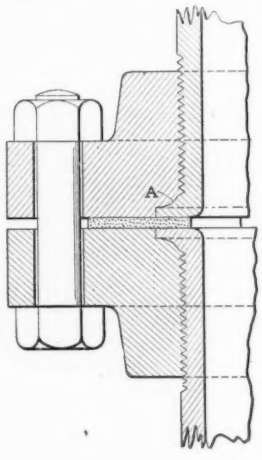


FIG. 2. SCREWED AND PEENED JOINT

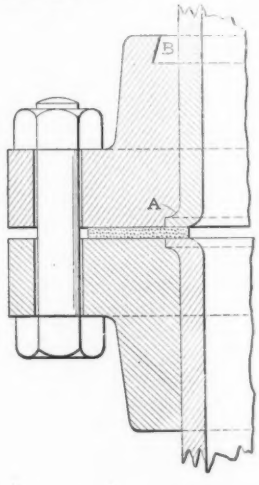


FIG. 3. SHRUNK AND PEENED JOINT

Shrunk, Peened and Riveted Joints

As pipe over 18 inches in diameter cannot be easily threaded, the flanges are riveted, shrunk, shrunk and peened, riveted and peened, or both shrunk and riveted on and then peened, all according to the judgment of the engineer. This also applies to smaller pipe.

Shrunk Joints—In making the shrunk joint the flange is accurately bored out to a diameter slightly less than the finished outside diameter of the pipe. When heated to the proper temperature, the flange expands and is forced over the end of the pipe. In cooling, the flange contracts and hugs the pipe all around its outer circumference with tremendous force. This, however, does not always insure a tight joint, and in most cases the outside of the pipe is turned true before shrinking on the flange.

Shrunk and Peened Joints—An ordinary joint of this type is shown in Fig. 3. The flange is shrunk on the pipe, as previously described, leaving a short length of pipe projecting beyond the face of the flange. The end of the pipe is then peened or rolled into the recess *A* in a manner similar to the screwed and peened joint. If so desired, the joint can also be made with a calking recess in the hub of the flange, as shown at *B*. Then should a leak develop between the flange and the pipe, the recess *B* can be calked with soft copper, as described for Fig. 1.

Riveted Joints—It is difficult to make a plain riveted joint that will remain tight for any length of time after it is under pressure, especially where cast-iron flanges

are used. For work of this kind the flanges should preferably be of rolled steel or pressed steel. Riveted joints are more often used for exhaust steam mains in the larger sizes than for high-pressure work.

It was a custom among several of the prominent manufacturers, before welding

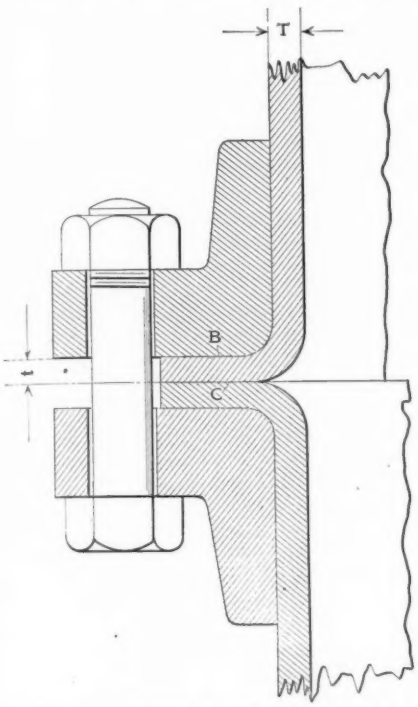


FIG. 4. ORIGINAL VAN STONE JOINT

There are many other joints in use, both in America and Europe, similar in many respects to the above, for which space is not available.

Van Stone or Lap Joints

Since the introduction of superheated steam more attention has been devoted to the details of piping systems. Valves have changed considerably. All cast-iron valves and fittings are rapidly being replaced by those made of cast steel, and in a like manner the joints previously described are being replaced by the Van Stone or lap joint.

Fig. 4 shows the Van Stone joint, of which the Lumsden & Van Stone Company, of Boston, Mass., was the originator. With joints of this type there is no possibility of a leak occurring between the pipe and the flange. In making this joint the flange is bored out to fit loosely over the pipe. The end of the pipe is then heated to the proper temperature and rolled or lapped over the face of the flange, as shown at *B*, the outer edge of the lapped portion coming just inside of the bolt holes. The faces of the laps at *C* are then turned off true in a lathe perpendicular to the axis of the pipe, and the joint is either made up metal to metal by grinding both faces of the lap, thus making a ground joint, or both faces are finished and a suitable gasket placed between them. Any good metallic or vulcanized gasket

finished lap is considerably less than that of the pipe itself. This is illustrated in Fig. 5, which shows a Van Stone joint before and after facing perpendicular to the axis of the pipe. The drawing is exaggerated for clearness. The original thickness of the pipe is shown at *T*, and

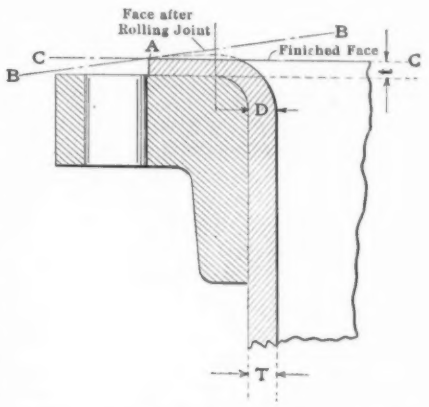


FIG. 5. VAN STONE JOINT BEFORE AND AFTER FACING

the thickness of the lap after facing front and back at *t*. Line *B B*, exaggerated also for clearness, shows the outward bevel of the face of the lap after rolling, due to the gradual thinning down of the metal, from the point *D* to the outer edge of the lap at *A*.

The method of constructing the joints

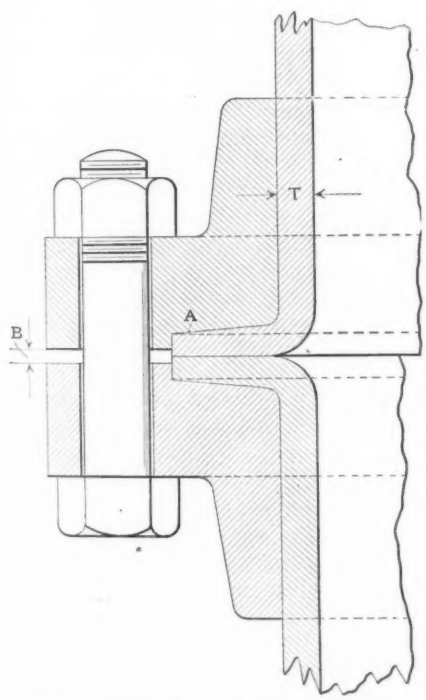


FIG. 6. IMPROVED RECESSED LAP JOINT

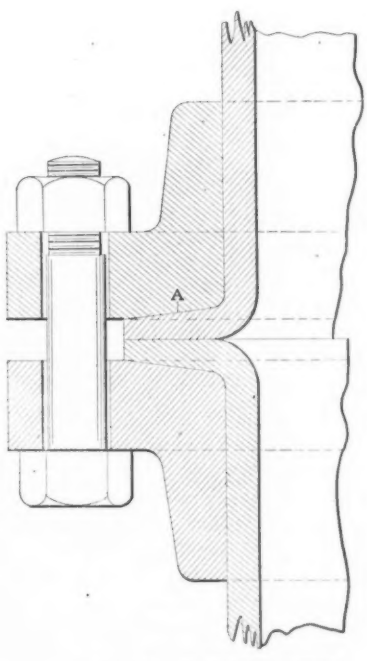


FIG. 7. CRANELAP JOINT

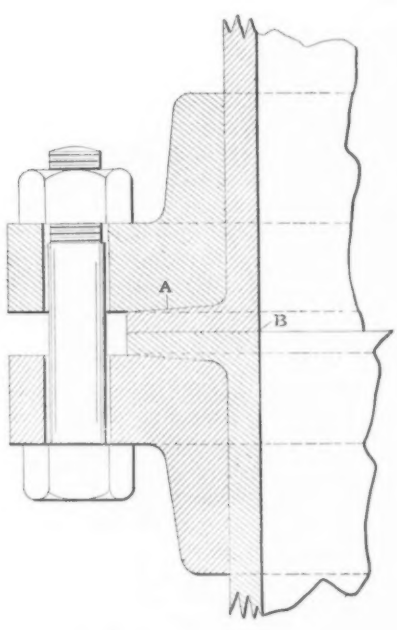


FIG. 8. IMPROVED CRANELAP JOINT

became as popular as it is today, to rivet nozzles to openings cut in the side of another pipe, making what is known as the riveted header. These nozzles in most cases are now welded on, making a more efficient joint in all respects for high-pressure work.

suitable for high-pressure superheated steam may be used.

By the ordinary method of flanging or lapping the pipe over the face of the flange the metal is thinned down considerably, so that when faced off front and back, *B* and *C*, the thickness of the

shown in Figs. 6, 7 and 8 is to bevel the face of the flange to the width of the lap to compensate for the difference in the thickness of the pipe between the inside and outside portions of the lap. The inward bevel of the face of the flange is shown at *A*. This brings the face of the

joint almost true after rolling, only a light cut over the face being necessary in finishing.

Fig. 6 shows the improved recessed joint made by W. K. Mitchell & Co., of Philadelphia, Penn. The pipe is turned over on the face of the flange to within ¼ inch of the bolt holes. The flange is recessed on its face to receive the lapped-over portion of the pipe, but the lap is allowed to extend about 1/32 inch above the face of the flange to give a good bearing for the gasket.

Fig. 7 is the Cranelap joint, and Fig. 8 an improved type of this joint. The improvement consists in upsetting and rolling the joint flat and square at the inside edge, as shown at *B*, giving a much wider bearing for the gasket. These joints are made by the Crane Company, of Chicago.

Fig. 9 shows the Whitlock joint, made by the Whitlock Coil Pipe Company, of Hartford, Conn. This might be called a double-lap joint. In making it the end of the pipe is heated and doubled back on itself, as it were, when rolling or lapping the pipe over the face of the flange. This is shown by the dotted line *C*. The pipe is upset slightly at the inner edge *B* and outer edge *E* to square up the face of the joint before finishing. The joint is then faced off true in a lathe perpendicular to the axis of the pipe. The thickness *A* of the metal after facing is equal to, or greater than, the original thickness of the pipe *T*. This method also gives a wide bearing for the gasket, as shown at *B*, and the pipe is strengthened at the corner *F*, where the lap joins the main body of the pipe.

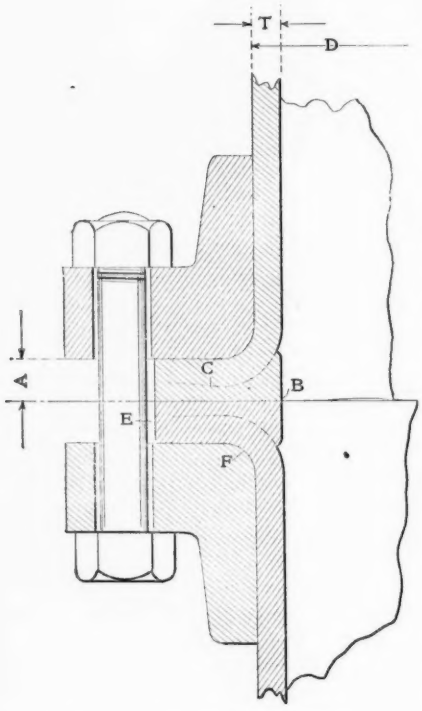


FIG. 9. THE WHITLOCK JOINT

In Fig. 10 is shown the improved Van Stone joint made by the M. W. Kellogg Company, Jersey City, N. J. After facing, the flange is bored to a taper of 1/16 inch. In the drawing, *D* represents the outside diameter of the pipe, *T* the original thickness of the pipe, and *W* the hight of the flange from the face to the end of the hub. The flange fits loosely over the end of the pipe. In making the joint, the pipe is first reinforced by securely welding a wedge-shaped band on the end of the pipe all around the outer circumference, doubling the thickness of the pipe at the extreme end. The dotted line *C* shows the position of the band after lapping or rolling the end of the pipe over the face of the flange, and finishing the joint on the front and back. The thickness of the pipe at *B*, where the lap joins the main body of the pipe, is approximately 1⅝ *T* or greater. The thickness of the lap is equal to or greater than *T* in all cases after finishing.

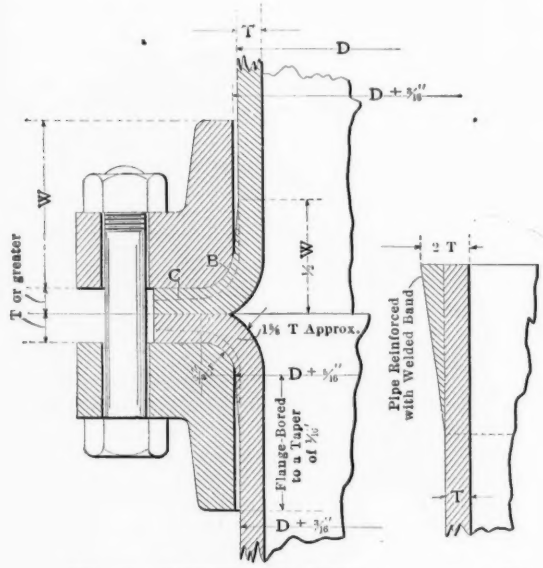


FIG. 10. IMPROVED VAN STONE JOINT

Fig. 11 shows a Van Stone hydraulic joint, also made by the Kellogg company. The upper flange is recessed at *A*, thus covering the edge of the joint to prevent the gasket from blowing out at the higher pressures. This recessed flange is also used in connection with the improved Van Stone joint shown in Fig. 10, the joint being the same in all other respects.

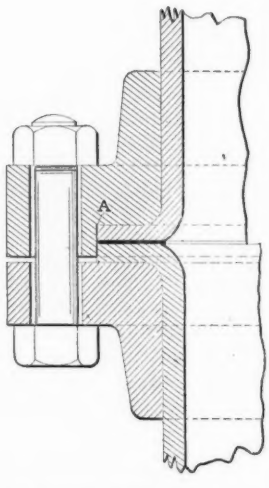


FIG. 11. VAN STONE HYDRAULIC JOINT

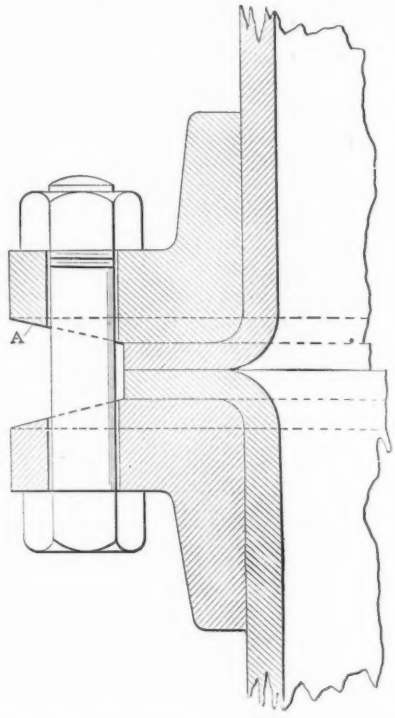


FIG. 12. VAN STONE JOINT WITH BEVELED FLANGES

Fig. 12 shows a Van Stone or lapped joint sometimes used in connection with a flange having the face beveled at *A*, making the gasket more accessible for removing or renewing.

The flanges on the Van Stone joints just described are loose and swivel, a fact appreciated by erecting engineers, as it becomes necessary at times to change the position of the flanges to bring the bolt holes into line when erecting. The flange can be revolved to the desired position. These flanges may be of cast iron, cast steel or rolled steel. The rolled-steel flange is to be preferred where the extra cost is not prohibitive.

Joints of the Van Stone type should be faced off on the back of the lap, as well as on the front, in order to insure a tight joint, as scale is formed on the back when the pipe is put through the process of heating and flanging. This scale, unless removed, falls off in spots, leaving a recess between the pipe and the flange and allowing the flange to settle unevenly against the turned-over portion of the pipe. Although the joint may be tight

when first erected in the line, in time the scale is likely to crumble and fall away, allowing the flange to settle closer against the back of the lap, which will lessen the tension of the bolts and cause the joint to leak.

Another method has been tried for reinforcing the metal at the face of the lap. It consists in upsetting the end of the pipe before flanging. This does not give the increased thickness and strength at the place where most required; namely, at the corner where the lap joins the main body of the pipe. It is also known that excessive upsetting has a tendency to crystalize and consequently weaken the fibers of the material.

Van Stone or lapped joints are made in sizes from 4 inches up. For smaller sizes, as a general rule, the screwed joint is used, and where properly made gives excellent results. Or, if so desired, the flanges can be welded directly to the pipe, both in the small and large sizes.

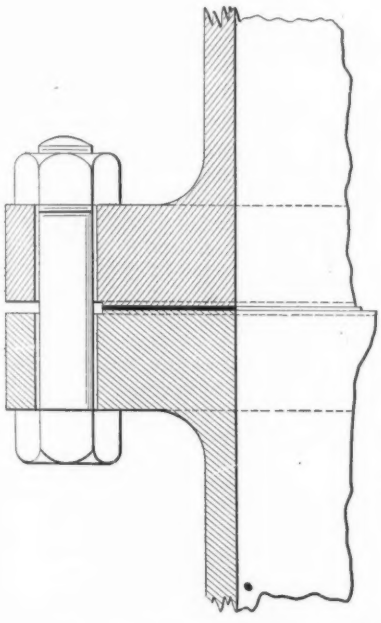


FIG. 13. FLANGE WELDED TO PIPE

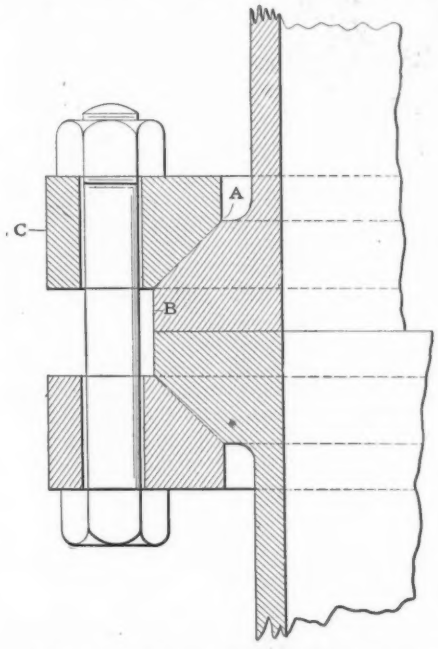


FIG. 14. WELDED OR UPSET ENDS WITH LOOSE TAPERED RING FLANGE

Welded Flanges

The practice of welding flanges to pipe is by no means new, having been accomplished satisfactorily in Europe for some 19 years or more, especially in Germany and England. Many firms in America are now doing this work, to meet the ever increasing demand for a metal-to-metal joint of the welded type. The ordinary method of welding by mechanical means, such as hammering or rolling, is not used as extensively as in the past, due to the fact that the strength of a weld made in this manner is uncertain. There has recently come into use a system known as autogenous welding, in which the metal itself is raised to a temperature sufficiently high to cause it to be its own joining material; that is, the parts to be welded are joined together by the fusion of their own substances without mechanical aid. By this method pipes are welded together, making any required length in one piece, and even separators and other steam appliances are welded up in the same manner, forming a homogeneous mass of uniform quality throughout.

A welded flanged joint is shown in Fig. 13. As will be noted, the flanges do not swivel on the pipe. For this reason the Van Stone joint is often preferred for erection purposes. Fig. 14 illustrates a type of welded joint much used on the Continent and to some extent in America. The flange *B* is either upset or welded to the pipe and beveled off at 45 degrees, as shown at *A*, to match the bevel on the loose-ring flange *C* directly above it. With this arrangement the bolt holes can be brought into line when erecting by turning the flange *C* to the desired position. The welded flanged joint makes the most perfect and workmanlike joint in use at the present time if properly made.

In a number of tests recently made to determine the strength of welded joints, the metal showed an average loss in tensile strength of about 10 per cent. at the weld for equal areas. These welds were made by skilled workmen using modern methods. It is good practice to reinforce the metal at this point to insure the weld being as strong as or stronger than the pipe itself.

The Pennsylvania railroad commission recently issued a circular to every steam-railroad company in the State, to ascertain what is being done to prevent explosions and other accidents to boilers.

Electrolysis and Superheat

By Thomas Sawyer

I have seen a great deal in the technical press lately about the destruction of condenser tubes, but I have seen nothing at all, as far as I can remember, about the corrosion, erosion or electrolysis of pump cylinders. I was once employed for a long time in a power plant where the eating away of portions of pumps by what looked to me like electrolysis or galvanic action was a matter for serious consideration. Surface condensers with salt-water circulation were used, and every cylinder in which salt water was used suffered. In one cylinder it would be the back head, in another it would be the front head, and in still another it would be the valve deck or some part of the cylinder at or near the end of the brass cylinder lining.

The engineer always claimed that there was from some source an electric current passing over or through the pump to the water, and that where it left the pump for the water it took some of the iron along with it. He searched for "grounds" inside the plant and succeeded in getting all that could be found transferred outside of the station, but this did not appear to help matters much, so he settled down to the practice of keeping circulating-pump parts in stock, ready for instant use whenever a replacement was necessary. He got all sorts of advice from all sources and tried some of the remedies suggested.

One friend told him that the devouring element, whatever it was, was caused by acid in the water and that acid must have something to eat. It ate the cast-iron pump cylinder because that was easiest dissolved, but zinc being more easily dissolved in acid than iron, it could be introduced into the water space of the pump, where it would be eaten instead of the higher-priced pump cylinder. Zinc was tried with no change in the rate of decomposition of the pump cylinder that could be noted, and absolutely no effect on the zinc except to brighten the surface slightly where it rubbed on the iron.

There was one pump in the plant where the corrosion was confined to the valve deck, and in a few months the valve seats would become loose and drop out. It was decided to put in a brass cylinder in place of the cast-iron one, it being argued that the current would not eat brass, and if there were no cast iron for the current to eat it would leave the pump for the water without doing any damage. The life of a cast-iron cylinder had been from a year to fifteen months. The brass cylinder ran about three months when the valve deck began to shed its seats at a rate never equaled by the iron cylinder in its palmiest days.

It seems that the electric current had such an affection for the brass valve seat

and stem that it would not leave for the water without taking along quite a bit of the material with which it had been associating. Here is a photograph (Fig. 1) of a valve stem and also a valve seat, which will give you some idea of how the wasting of the material is going on. It

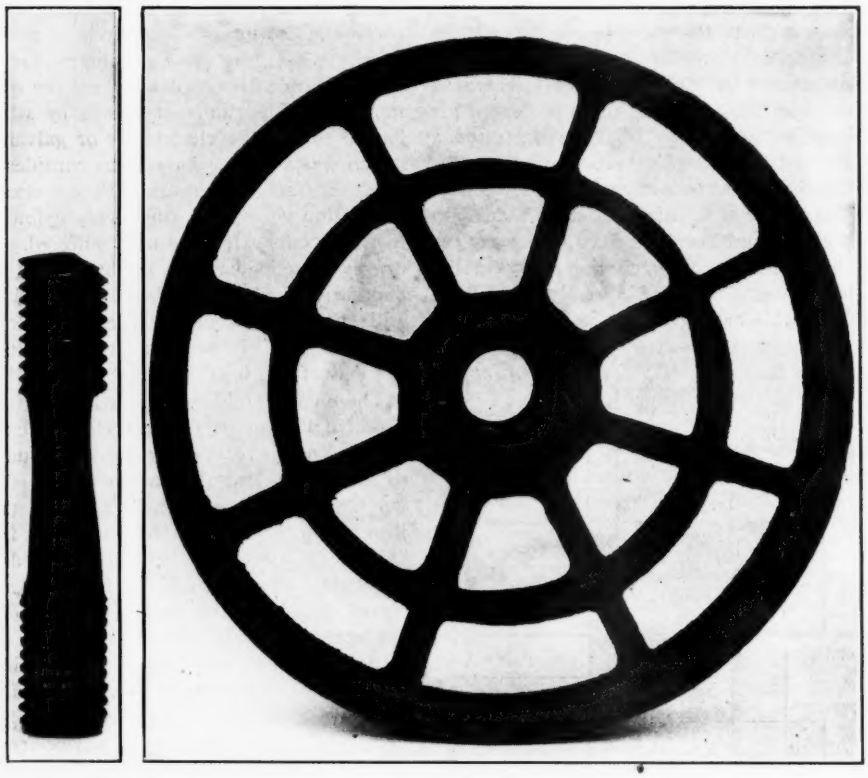


FIG. 1. VALVE STEM AND SEAT, SHOWING THE DEGREE OF WASTING AWAY

would seem that the outside of the valve stem is softened by the passage of the current, and in its soft state is rapidly worn away by the friction of the rubber valve. At one end there is quite a pit, about ¼ inch deep, and the pit has a copper-colored appearance, as though the zinc had been eaten out of the composition of which the stem is made, leaving the copper to be washed away by the water; from the photograph of the valve seat it can easily be seen how the wasting process has attacked both the face of the seat ring and the radial ribs. These radial ribs were originally about ¼ inch thick. Some of them are wasted away to a knife edge and considerably below the face of the valve seat. On the opposite side of the valve seat the face of the valve is depressed nearly ¼ inch where the rubber valve has worn the top surface material away.

This matter is particularly interesting to me because in no other plant that I have visited have I seen the destruction of pump cylinders, valve decks, valve stems, valve seats, etc., carried on to such an extent, and I am at a loss to account for it. At certain portions of the day some sewage which possibly might contain nitrates is carried through the different pumps in the condensing system, but the greater part of the wasting away takes place entirely in this single pump cylinder.

The usual brass valve guards on the upper end of the valve stems are being replaced with cast-iron ones, in the hope that in the escape of the current from the pump to the water it will take iron along instead of brass. These small guards are cheap and if the action can be confined to them it will in a measure solve one engineer's problem. Of course, everyone knows that the proper way to cure any ill is to remove the cause, but in this case it seems that the cause is undiscoverable. It may come from the electric-car line half a mile away, or it may come from some cause in the plant itself. Anyway, the problem is an interesting one and I shall watch developments with interest.

At this same plant a change was made from horizontal return-tubular boilers to water-tube boilers with superheaters, and no end of annoyance has followed the change. I know editors say that there is or need be no trouble in using superheated steam if the pipe and fittings used are of the right kind. That may be true as regards pipe and fittings, but we did not learn it soon enough. These boilers were installed under a guarantee to give 100 degrees superheat to the steam when working at their rated horsepower, which guarantee I think was met, for I found 120 degrees superheat at a turbine throttle 120 feet from the boiler.

An amusing incident occurred one day when I started to take the temperature of the steam. We were using a steam pressure of 115 pounds and as I took the cover from the thermometer well, I looked around for something to clean out what dirt might have got in before the cover was put on. I saw what looked like a short piece of wire lying on a tool box nearby. I took the wire and, winding a little wad of waste around it to catch the dirt, pushed it down into the well. For an instant I thought the well had no bottom, for the wire went right along down. When I pulled it out I had only about 2 inches left of what proved to be a piece of 30-ampere fuse wire. The well was nearly full of melted metal in which the thermometer was inserted when the temperature readings were wanted.

FIG. 2. WHAT WAS LEFT OF THE BRONZE VALVE SEAT

But I started to say something about superheat. The boilers and the new pipe line had all been equipped with special superheat valves which were all right until it was desired to close them. The first

set was of the automatic nonreturn type. In less than six months they had all failed and were replaced by ordinary heavyweight valves. These answered a little better, but one day there came a glib-tongued salesman, with confidence in his goods written all over his face and showing in every word and action. He had the real superheat-proof valve. It had been discovered, he said, that all the trouble with valves in the use of superheated steam came from the difference of expansion between the cast-iron body and the bronze seats. So the company chemist had set himself the task of creating a bronze for valves and seats which should have the same coefficient of expansion as the cast iron from which the body of the valve was made, and he had succeeded.

And here was a guaranteed valve ready for use in which the bronze parts would always retain their proper relation to the iron body because the bronze parts would always expand and contract with the iron and to the same extent with the same temperature.

No argument nor "jollying" seemed to shake the confidence of this salesman in the quality of his wares and a set of stop valves for the boilers was ordered.

One day not long ago one of the valves was closed, but the closing of the valve did not shut the boiler off and other valves were shut one after another until the faulty valve, the valve with a guarantee of a live salesman and a responsible company behind it, the valve with a new coefficient of expansion, could be examined. It was found to be seatless. Here is a photograph (Fig. 2) of that part of the seat which could be found. The missing segment from the ring must have evaporated in the intense heat of the superheated steam, for no trace of it has been discovered. It will be noticed from the photograph that the seat must have become quite loose in the body of the valve and that it had danced about considerably, wearing away the threads which at first held it in position.

Annual Dinner of the A. I. E. E.

The annual dinner of the American Institute of Electrical Engineers will be held on March 11 at the Hotel Astor, New York City, and will celebrate the completion of the first quarter of a century of the institute's existence. The historical significance of the gathering is receiving special consideration by the committee of arrangements appointed by President Louis A. Ferguson, which consists of T. C. Martin, chairman; G. H. Guy, secretary; T. Beran, M. Coster, M. M. Davis, H. A. Foster, G. A. Hamilton, R. T. Lozier, W. McClellan, F. A. Muschenheim, H. W. Pope, C W. Price, F. A. Scheffler, E. A. Sperry, A. Spies and A. Williams.

Steam and Electrical Equipment of the Ambrose Channel Lightship

By Warren O. Rogers

When an engineer passes a civil-service examination he is eligible for various engineering positions in the sundry departments of the United States Government. Among them is that of engineer and electrician on board a Government lightship. In order that a clear idea may be obtained as to what type of apparatus comprises the steam and electrical equipment of a modern lightship, a short description of the Ambrose channel lightship, formerly known as the Sandy Hook lightship, off the entrance to New York harbor, is given herewith.

The new Ambrose channel lightship is supplied with two Scotch boilers having two furnaces each, one boiler being shown in Fig. 1. These boilers generate steam for the different apparatus throughout the ship which are used for illuminating, signal lights, etc. Steam is also used for blowing the huge fog whistle in thick and stormy weather. The coal bunkers are placed along the sides of the ship, and hold a supply sufficient to last from four to five months.

In Fig. 2 is shown a vertical compound engine, with cylinders 16 and 36 inches in diameter and a stroke of 24 inches. It is direct-connected to a propeller shaft, the propeller being 7 feet 9 inches in diameter with a 10-inch pitch. This engine equipment will enable the lightship to regain its station in case it should break away from its moorings at any time. The engine runs condensing, as do the auxiliaries found throughout the ship. A surface condenser is used. The condensing system is quite a feature, as distilled water

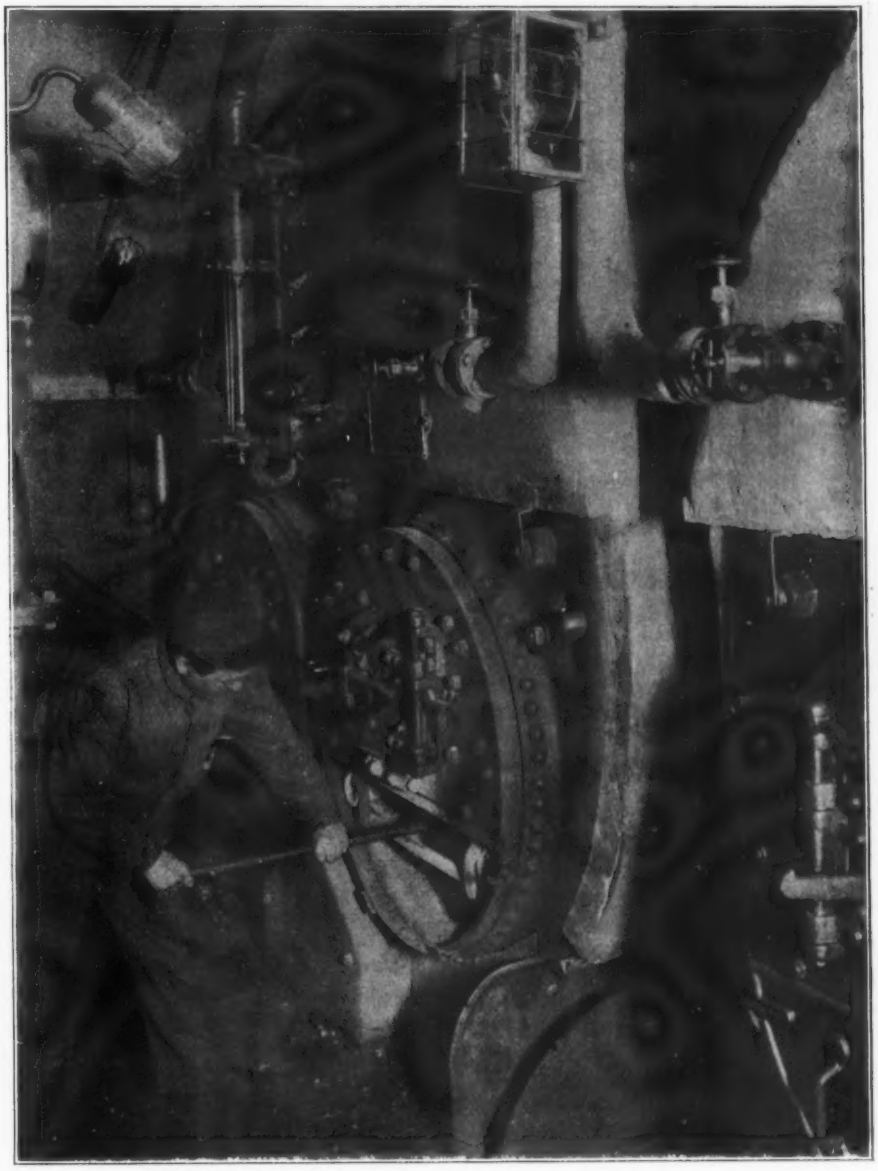


FIG. 1. SCOTCH BOILER ON SANDY HOOK LIGHTSHIP

is used for all purposes. The ship is equipped with an evaporating and distilling plant with a capacity of 2500 gallons per twenty-four hours.

In Fig. 3 are shown the two generating sets used for illuminating the ship throughout and also the masthead signal lights. The generating units are in duplicate, direct-connected to a marine-type vertical engine and have a capacity of 7 kilowatts. They are of the multipolar type with a working range in electromotive force of from 110 volts no load to 115 volts full load. The armatures are of the iron-clad, bar-wound ventilated type, the cores being built up of thin, double sheet-steel laminations, in the slots of which are carried interchangeable coils separately insulated. The brushes are designed with a means of independent or collective adjustment. The circuit switches feed their respective circuits directly, and connections are made so as to operate all lights from either generator set, or both.

The vessel is wired with a two-wire feed system to which are connected fifty-five 16-candlepower 110-volt incandescent lamps. Each circuit is placed in an iron-pipe conduit with a socket so designed as to make it absolutely steam- and water-tight.

The switchboard shown between the two generator sets controls the entire electric-lighting system of the ship. It will be seen that double-throw switches are arranged so that in case of accident to one generating set, the other can be put into service. The distributing switches are also of the double-throw type and so arranged that different circuits can be carried by one engine, or any combination can be made so that one engine or both engines may be used at once on any or all circuits. The engines operate either condensing or noncondensing.

The masthead signal lights consist of three 250-candlepower 100-volt tungsten lamps suspended 55 feet above the water level. They can be seen in clear weather for 13 miles. These lamps, which are carried on the fore and main masts, are also arranged so that each can be switched onto either generator, which prevents any discontinuance of the light in case of accident to either one of the generating units. In the rear of the switchboard is the device for flashing the masthead lights, by which arrangement the lights are flashed for a certain interval and then remain dark for a certain interval, the current being automatically cut in and out. This timing device can be changed so that the period of lighting and the period of lamp extinction can be varied to suit any desired timing.

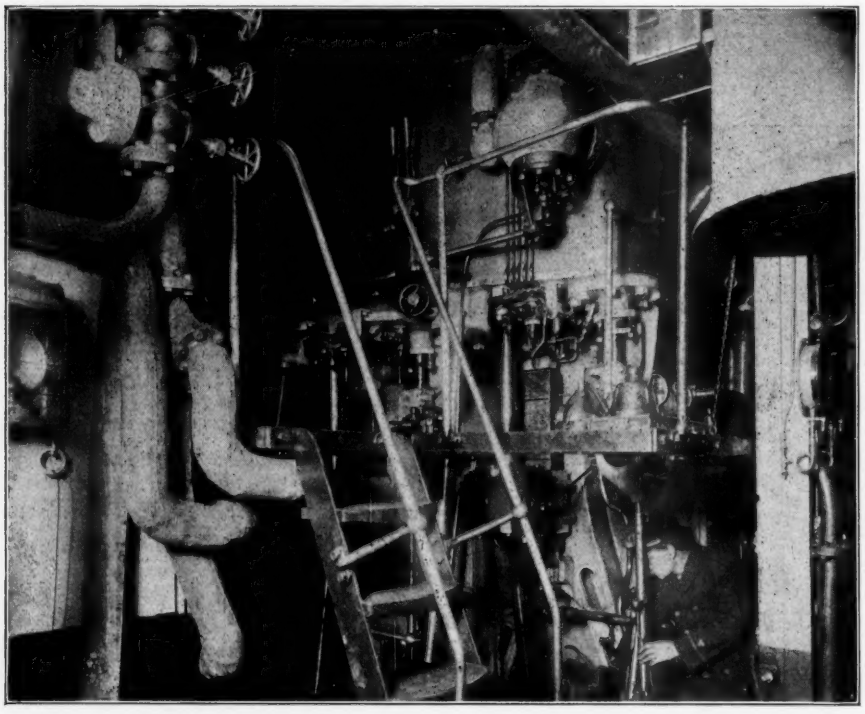


FIG. 2. VERTICAL COMPOUND ENGINE ON LIGHTSHIP

In Fig. 4 is shown a section of the upper-deck engine room which is directly over the grating of the main engine. In the corner shown will be seen a boiler-feed pump and also a small vertical engine used when operating the large fog whistle. This whistle obtains steam from a 4x12-foot wrought-iron steam drum which is connected to the boilers by short pipe connections. The steam drum was found to be necessary in order to get dry steam, as without it water would be drawn from the boilers. The whistle is so arranged that it blows for a definite period and then is silent for a definite period. The whistle blast is timed by means of blocks, the blast of the whistle representing the time it requires for the whistle lever to pass over a block and drop to its lowest position, when the whistle remains silent. When the whistle lever is again lifted by a block, its motion opens the valve in the whistle pipe and the whistle blows until the lever reaches the end of the block and drops to its lowest position again. These blocks are placed in a revolving plate and can be spaced as desired.

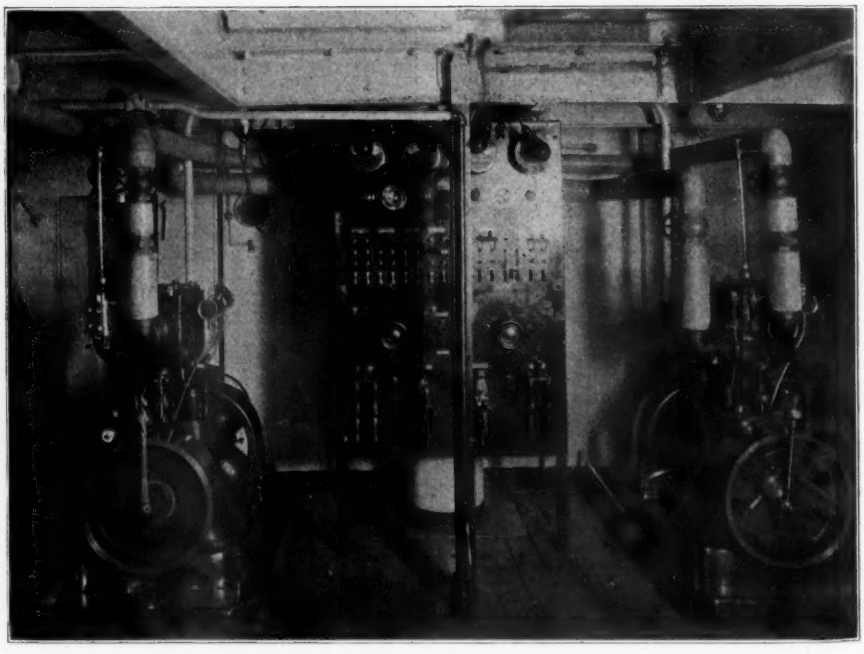


FIG. 3. GENERATING SETS ON LIGHTSHIP

On the other side of this upper-deck engine room is arranged a small vertical engine direct-connected to an air compressor. This air compressor furnishes air to the deep-sea bell of the same type which figured as an important factor in the recent collision of the steamships

"Republic" and "Florida," the bell being the means of guiding the rescuing steamship to the disabled steamer.

The operation of this bell is as follows: The bell, connected to a water-tight casing at the top, in which is a diaphragm, is suspended over the side of the ship and submerged in the water. To the top of the bell containing the diaphragm are connected two rubber pipes, which are in turn attached to the receiver of the air compressor. This bell is arranged to operate automatically by a timing device striking the number of the ship, which in this case is 22. As the air is admitted to the diaphragm and released it operates the bell clapper, which, striking the bell, sends its tone through the water for about 10 miles in all directions from the ship. The officers of a ship within that zone, if equipped with a receiving apparatus, are enabled to estimate the distance they may be from the lightship. There are usually two receivers on ships equipped with this device, and in order to determine the exact position of the warning signal, the ear is applied first to one and then the other, the one giving out the loudest tone indicating upon which side of the ship the lightship is located. In this way, the officers are enabled to determine their exact position.

The Ambrose channel lightship is said to be the best equipped lightship in the world, modern in every particular and built to withstand the heaviest sea. The writer is indebted to A. B. Conover, superintendent of the lighthouse department, Tompkinsville, S. I., for data, etc., pertaining to this lightship.

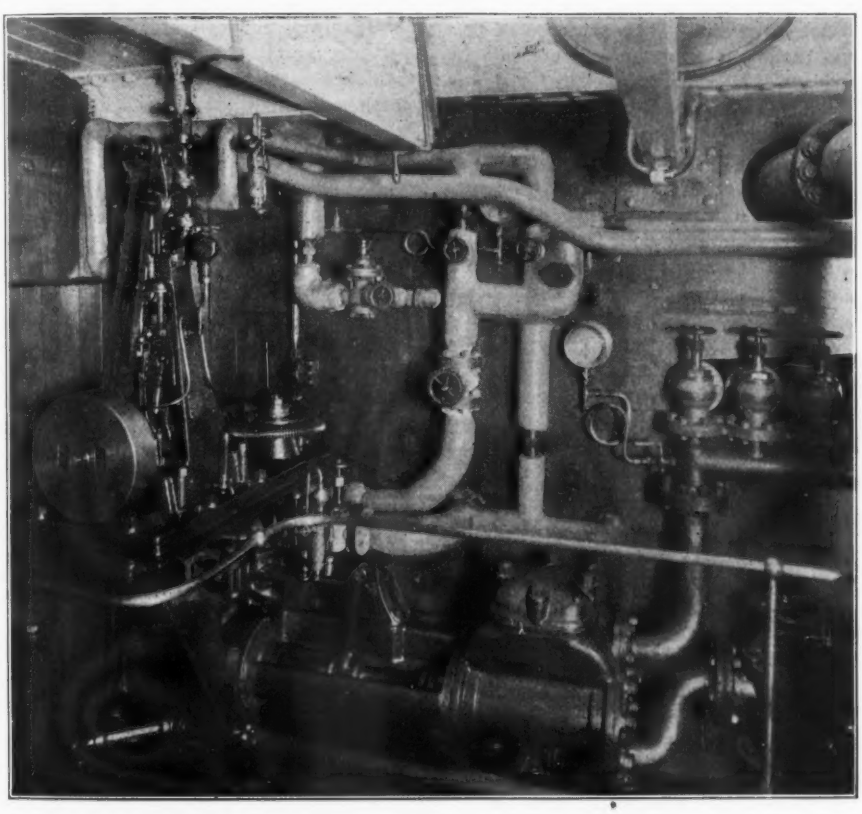


FIG. 4. PART OF THE UPPER-DECK ENGINE ROOM

Proposed Mammoth Testing Machine for the Government

On January 28, Senator Teller introduced into the United States Senate a bill for the purchase of an Emery testing machine of large proportions, this machine to be designed by A. H. Emery, builder of the famous testing machine at the Watertown arsenal, which was tested for acceptance in 1879. The proposed machine is to be able to give and weigh loads of tension up to 11,000,000 pounds, and loads of compression up to 22,000,000 pounds, on specimens up to 100 feet or more in length. The main loading platforms for testing bridge-compression members, columns, etc., are to be not less than 8 feet wide and 12 feet long and are to be adapted to receive auxiliary holders and platforms. The machine, if built, will have tension holders to seize and test to destruction round, square and rectangular bars with loads up to 3,300,000 pounds on lengths up to 100 feet or more; a pair of holders together with their pins and bushings for testing bridge links up to 100 feet or more in length under all loads up to 11,000,000 pounds; an auxiliary pair of compression platforms with hardened faces for testing stone, etc., with all loads up to 22,000,000 pounds, and a pair of auxiliary platforms with pins 24 inches in diameter and 8 feet long for testing pin-ended columns with loads up to 22,000,000 pounds. A pair of 80-ton electric cranes and the ways for them to run on are proposed for the erection and use of the testing machine, also the necessary hydraulic pumps and their electric motors for the operation of the presses.

The contract price for the machine complete with its foundations erected in place, together with its accessories, is to be $1,750,000 and the bill provides for an additional sum of $200,000 for a building in which to place the testing outfit. As designed, the main part of the machine is about 153 feet long, while the concrete foundation is about 200 feet long, 30 feet wide and 15 feet deep, and the metal work in these foundations is about 192 feet long; the width of the machine to be about 25 feet. The weight of the metal work, including that in the accessories, cranes, and the metal work of their ways, will be approximately 3500 net tons, mostly of steel, and a large part of the machine will have to be of unusually good workmanship and generally much better and more accurate than has been put in any large machine of any kind whatever.

It is to be hoped that the bill will pass.

National Gas and Gasolene Engine Trades Association

There was a meeting of the National Gas and Gasolene Engine Trades Association at the Auditorium hotel, Chicago, on Tuesday, February 9. After routine business at the morning session there was a general discussion of the possibilities and the lines along which future effort should be directed. This discussion was very general and the officers and executive committee received a number of suggestions which will be incorporated in the future work. J. A. Williams, of the K-W Ignition Company, Cleveland, O., then read a very interesting paper on ignition, bringing out new points of the ignition of stationary, marine and automobile engines.

At the afternoon session, C. O. Hamilton, of the Elyria Gas Engine Company, Elyria, O., opened a discussion on the "Proper Horsepower Rating of Gas and Gasolene Engines."

A. L. Haskell, of the National Carbon Company, talked on "Multiple Series Wiring of Dry Batteries." Following this, George M. McCormack, Jr., of the Rockford Engine Works, read a paper on "Education the True Solution of Our Troubles."

Following Mr. Cormack's paper there was an announcement by the president of a number of committees which are to take up special subjects with reference to special investigation for future benefit of the association. It was also announced that the next meeting of the association would be held at South Bend, Ind., on June 22, 23 and 24.

Impurities Causing Scale and Corrosion*

General Characteristics of Salts, Gases and Acids Which Cause Scale or Corrosion in Boilers. Density of Water and Its Purification

BY J. C. WILLIAM GRETH

The chemist has shown the way in which to prevent scale and corrosion in boilers and also how to prevent losses in the industrial arts. His method is to remove from the water the objectionable salts which it contains by changing the soluble salts into insoluble precipitates, which can then be removed by sedimentation and filtration before the water is used. This process is rational in application, the results certain, and the cost in every case is but a small fraction of the advantage gained.

Natural water supplies furnish the water converted into steam; these supplies are rarely, if ever, pure, for water in its descent to the earth as rain absorbs carbonic acid, some air and other impurities. The carbonic acid absorbed enables it to dissolve certain salts of lime and magnesia. Other substances will be dissolved, depending upon the nature of the rocks, soil, vegetation, sewage and industrial waste with which it may come into contact.

Steam generation is a continuous process, fresh feed water being supplied to the boiler as the water evaporated into steam leaves it; this results in a continual concentration in the boiler of the impurities introduced with the feed water, since none but volatile impurities pass out with the steam. The nonvolatile impurities collecting in the boiler manifest themselves as suspended matter, scale, corrosion, or by an increased density of the boiler water.

The suspended matter may be carried in with the feed, or may be due to substances forced out of solution as a result of either heat or concentration, or both. Scale formation in the boiler is due to the action of heat, pressure, and concentration on the impurities in solution and suspension in the feed water. Corrosion of the boiler is due to the introduction of gases and acids, or their formation from some of the impurities in solution in the feed water, by the reactions resulting from heat, pressure and concentration. The increased density of the boiler water is due to the concentration of the sodium salts and of the scale-forming salts, to the limit of solubility.

Scale is the great bugbear which steam users, as a rule, fear, and make more or less of an effort to combat, and with good reason. Scale is one of the crucial items entering into boiler-operating costs. Scale can nearly always be attributed to the lime and magnesia salts in solution in the water. The character of the scale depends on the acids combined with the lime and magnesia; on the type of boiler in use, and on the rate, temperature and pressure at which the boiler is operated. For instance, the carbonates of lime and magnesia, when present alone, usually form a soft scale. The presence of calcium sulphate sometimes increases its hardness. A calcium-sulphate scale is generally quite hard.

The following are a few of the items which, from an economic standpoint, make it almost imperative to prevent scale formation, or at least to remove it periodically:

First. Reduced evaporation due to the insulating effect of the scale on the heating surfaces of the boiler.

Second. Cost of labor required for cleaning the boilers and auxiliaries.

Third. Cost of repairs to boilers, necessitated by their being subjected to overheating on account of the heating surfaces being scaled.

Fourth. Loss of efficiency and earning power of improved furnaces and stokers installed to increase evaporation, which correspondingly increases the concentration of impurities, thus forming a greater deposit of scale, and hence a greater reduction in the efficiency and life of the boilers.

Fifth. Cost of tube-cleaning machines, repairs to them, interest and depreciation on money invested, and labor and power required for operating them.

Sixth. Cost of boiler compounds, or any substances introduced into the boiler to prevent the adherence of the scale-forming matter to the shells and tubes.

Seventh. Loss due to the investment in spare boilers to be put into commission when it is necessary to take boilers out of service for cleaning or repairs.

Eighth. Waste of fuel due to heat lost in cooling a boiler for cleaning or repairs, and that required to bring it to steam again.

Ninth. Loss due to reduced efficiency of boiler auxiliaries, especially in the feed-water heaters and economizers, resulting in lower temperatures of feed water, thus materially increasing fuel consumption.

Salts Which Enter Into Scale Formation

Calcium Carbonate—This salt is in solution in natural waters as the bicarbonate. On heating the water, carbonic acid is driven off and the normal carbonate is precipitated to the limit of its solubility, which in distilled water is about two grains per U. S. gallon, but in waters containing other salts at boiler temperatures and pressures it varies from about one to five grains per U. S. gallon. This limit of solubility remains almost constant for a particular water under boiler-operating conditions. The precipitation of calcium carbonate by heat is practically complete at about 300 degrees Fahrenheit. The precipitation, however, starts as soon as the temperature of the water is raised and continues until the limit is reached. The precipitation therefore occurs, not instantaneously, but gradually, and with a diminution of precipitate as the limit of solubility is approached. This is true of all scale-forming salts that are precipitated by heat alone.

The amount of calcium carbonate left in solution in the water depends upon the other salts in solution. Heat alone will effect the removal of both the free and the half-bound carbonic acid; therefore calcium carbonate will be precipitated, and the precipitate may eventually deposit as scale. The formation of scale from precipitated calcium carbonate depends upon the other substances in solution and the conditions under which the boiler is operated. For instance, if the water contains sodium carbonate, the chances are that the calcium carbonate will be precipitated as sludge. If, on the other hand, the water contains calcium sulphate, the cementing action of the calcium sulphate will tend to form a hard scale, the hardness of which will depend upon the amount of calcium sulphate in solution in the water, and the rate, temperature and pressure under which the boiler operates.

Magnesium Carbonate—This substance has the same general characteristics as calcium carbonate, being held in solution as the bicarbonate. The normal magnesium carbonate, however, is more soluble than the normal calcium carbonate. Further, magnesium carbonate is quite easily dissociated as a result of heat, liberating carbonic acid and precipitating magnesium hydrate, which, at all temperatures, is very insoluble, rarely over one-half grain per U. S. gallon. The analysis of boiler blowoff waters will usually show both magnesium carbonate and magnesium hydrate in solution, while the scale will generally show magnesium hydrate.

Calcium Sulphate—This sulphate is solu-

*Abstract of paper read before the American Institute of Chemical Engineers.

ble in natural waters to over 100 grains per U. S. gallon, and under boiler temperatures and pressures to approximately 25 grains per U. S. gallon, depending upon the other salts in solution. It is quite generally stated that calcium sulphate is insoluble at 300 degrees Fahrenheit; this may be the case in a solution of calcium sulphate in distilled water, but it is not the case with natural water supplies or those containing other salts in solution. The analyses of hundreds of samples of blowoff waters show calcium sulphate present to the extent of 25 grains, where temperatures far above 300 degrees Fahrenheit are maintained. The amount held in solution at boiler temperatures depends upon the amount of other substances in solution, and also upon the rate of concentration of those impurities. Calcium sulphate generally gives a hard scale, deposited in layers. This is probably explained as follows:

In the boiler the calcium sulphate concentrates until it forms a supersaturated solution, from which, on agitation of some sort, it quickly deposits a mass of densely interlacing hard crystals of gypsum, until its concentration drops to the point of saturation. Further, concentration in the boiler again forms the supersaturated solution, from which later another crystallization occurs. These repeated periodic crystallizations of white gypsum, separated by the slow, constant and regular deposition of other scale, would give the laminated appearance generally seen in a calcium-sulphate scale.

Magnesium Sulphate—This substance at boiler temperatures is quite soluble, and when present alone is not likely to form scale, but in the presence of calcium carbonate will react with it, forming magnesium carbonate and calcium sulphate. Magnesium sulphate is also objectionable because it reacts with sodium chloride, forming the very soluble sodium sulphate and magnesium chloride. This reaction is the result of heat and concentration in the boiler.

Calcium Chloride—This lime salt is very soluble at all temperatures, its solubility increasing with the temperature. It is, however, a fact that with the increase of calcium chloride as a result of concentration, a point is reached where the calcium chloride begins to be dissociated, forming calcium hydrate and hydrochloric acid. The calcium hydrate is quite insoluble at boiler temperatures. Analyses of scale and sludge from boilers fed with water containing much calcium chloride show calcium hydrate, and evidences of corrosion, no doubt due to hydrochloric acid, are usually found. The calcium hydrate formed as a result of this reaction may combine with carbonic acid, either introduced with the feed water or that liberated as a result of heat, and form calcium carbonate.

Magnesium Chloride—This chloride has the same general characteristics as calcium chloride, except that it is more easily dissociated, and whenever present, scale and corrosion result. The scale is due to the magnesium hydrate precipitated, and the corrosion, to the hydrochloric acid liberated. In waters containing calcium carbonate, the hydrochloric acid thus formed may be neutralized by the calcium carbonate, forming the calcium chloride and liberating carbonic acid.

Calcium and Magnesium Nitrates—These salts have the same general characteristics as the calcium and magnesium chlorides, but the quantities present in most feed waters are usually so small that not much consideration is given to them. However, there are some water supplies in which these salts are present to such an extent as to cause both scale and corrosion.

Silica—The silica in solution in a water usually does not exceed two or three grains per U. S. gallon, and by itself will not form scale, but it is always found in the scale when present in the feed water. Silica under boiler temperatures may react with sodium chloride, forming a sodium silicate and liberating hydrochloric acid.

Oxides of Iron and Alumina—These are not usually present to any great extent, but by concentration enter into the formation of scale.

Organic Matter—The substances included under this general term play an important part in the formation of scale, and in many cases when present cause the formation of a hard scale which otherwise might be quite soft. The reverse is also true with some forms of organic matter. Then, again, some organic matter may prevent the formation of scale by increasing the solubility of some of the lime and magnesia salts.

Sodium Salts—These are present in nearly all water supplies and cannot be classed as scale-forming matter, although present to a slight extent in nearly all scale; this is due to their being present in solution in the water, mechanically held by the scale, rather than from being forced out of solution, for long before such saturation is reached, it becomes impossible to operate the boiler.

Corrosion—Corrosion is the most dangerous of the various troubles due to impure feed water, and the one in many cases the most difficult to overcome. It is usually due to the acids introduced into the boiler in the feed water, or those formed as a result of reactions between various substances in solution, caused by heat and concentration; in some cases it is due to the oxygen of dissolved air. The different acids cause different kinds of corrosion, and it occurs in different parts of the boiler, depending upon the nature of the acid.

Gases and Acids Entering Boiler and Causing Corrosion

Oxygen—Nearly all waters contain more or less oxygen dissolved from the air. The oxygen of the air is more soluble than the nitrogen, and is frequently the cause of pitting and grooving, especially in those parts of the boiler where the temperature is low and the circulation slow, such as, for instance, in the mud drums of those types of boiler in which the mud drum is not in the direct path of circulation. The corrosion by oxygen is the direct formation of the various oxides of iron. It is next to impossible to overcome this form of corrosion, as there is no practical way of removing the dissolved oxygen from the water. The corrosion, however, is of a mild form and does not, except in rare cases, cause much trouble. The cases where trouble from this source is experienced can almost always be charged to the design of the boiler, for if the circulation is as rapid as it should be and all of the boiler water moving, the oxygen will go off with the steam, possibly causing some corrosion at or above the water line, but not generally to an appreciable extent.

Carbonic Acid—This acid, which is mixed with the air to the extent of about 0.04 of 1 per cent., is present in all natural water supplies. It is absorbed by the water, in which it is quite soluble, from the air. The corrosion caused by carbonic acid is usually indicated by pitting and grooving, and it is shown not only in the water space of the boiler, but also above the water line and in steam lines. Its corrosive action is much greater when oxygen is present with it.

Hydrochloric Acid—This acid is rarely if ever present in natural waters, but is formed as a result of the decomposition of some of the chlorides, and reactions between such substances as magnesium sulphate and sodium chloride, and attacks surfaces exposed to steam. Hydrochloric acid is volatile, also very soluble; therefore corrosion is shown both above and below the water line. This acid attacks the iron, forming the unstable iron chloride which, at boiler temperatures, is dissociated; the iron being precipitated as the oxide, or hydrate, and the acid thus liberated combines with more iron from the boiler, and is in turn again set free. In this way the corrosion goes on indefinitely, constantly increasing in its action on account of the continued increase in the acid contents of the water by the acid that is liberated from the impurities in the water being added to the acid formed by the decomposition of the iron chloride. This concentration of the acid does not take place above the water line, but the heat there is sufficient to dissociate the iron chloride. Corrosion from this cause is usually shown by pitting and grooving, rather than over the entire surface.

Sulphuric Acid—When this acid is present in a natural water supply it is due to drainage from coal mines or industrial plants. It is not volatile and its action shows only below the water line. Its

action on the iron of the boiler is similar to that of hydrochloric acid, except that it forms the iron sulphate, which in turn is dissociated into sulphuric acid and the iron oxide or hydrate. This iron oxide usually forms a part of the scale, or is present in the water as suspended matter, giving to the water the characteristic red color of iron rust. A feed water containing only a small amount of sulphuric acid will produce active corrosion, resulting in the destruction of the boiler, on account of the continual formation of iron sulphate and its dissociation into sulphuric acid and iron oxide or hydrate. Many water supplies, especially those contaminated with the waste from galvanizing plants, contain iron sulphate, which, under boiler temperatures, is immediately dissociated.

Organic Acids—Under this head are included acids such as tannic and acetic. They are usually the result of contamination from vegetable or organic matter. The corrosion from organic acids is comparatively mild, but occurs to a greater or less extent, and is very similar to that from the other acids. However, the amount of such acids present in most waters is usually so small that little attention need be paid to it.

Density of Water in Boilers

The increase in density of the water in the boiler cannot be prevented, for the evaporation of water into steam leaves the sodium salts in solution; and there is no means by which these salts can be removed from the water, either before or after it enters the boiler. By frequent blowing off the concentration of the sodium salts in the water in the boiler can be reduced, but not entirely prevented.

That portion of the scale-forming salts soluble at boiler temperatures and pressures also increases the density of the water, but these salts are constantly concentrating and precipitating, so that after a certain point is reached for uniform pressure and rate of operation, the analysis of boiler water will remain practically the same, with the exception of a variation in the calcium sulphate and an increase in the sodium salts.

Scale and corrosion are closely related, because of the number of salts which, as a result of heat and concentration, either decompose or react, forming salts and liberating acids; the precipitated salts forming scale and the acids causing corrosion.

The analysis of the water is of undoubted value in determining the substances in solution. There is, however, among chemists a wide difference of opinion as to the proper method of making combinations from the determinations of the various substances in solution. Experience enables a chemist to formulate certain rules, and by careful observation during the course of the analysis, to note the salts present in a particular water. But in reporting the nature of the possible scale formed by a certain water, or the corrosion which might result from its use, not only the analysis of the water must be taken into consideration, but the reactions between the various salts in solution; these reactions, however, do not take place to the same extent in all waters. The amount of scale-forming impurity in the feed water rarely if ever bears a direct relation to the substances in solution in the water after concentration in the boiler, but it does to the amount of scale or sludge formed. However, there is a close relation between the amount of sodium salts introduced with the feed water and the amount found in the boiler water after concentration; this ratio indicating approximately the number of concentrations.

It cannot be definitely foretold that in a certain water containing both magnesium sulphate and sodium chloride there will be a reaction between these salts, yet hundreds of blowoff analyses show the results of these reactions, and the boilers show corrosion resulting from the liberated hydrochloric acid.

It therefore means a careful study of the water and the conditions under which the boiler operates, to determine whether scale or corrosion would result from the use of a certain water. It is almost impossible to predetermine the nature of scale from the analysis of the water. The only safe way is to feed water into the boilers, free from those substances which scale and corrode. Such general statements that waters containing only the carbonates of lime and magnesia will form a comparatively soft scale, and that the calcium sulphate will form a hard scale, and further, that it will increase the hardness of the carbonate scale, should be made with caution, for there are hundreds of instances where a hard scale is formed from waters containing only the carbonates of lime and magnesia, and also where the scale is quite soft in the presence of considerable calcium sulphate.

The nature and amount of scale formed in a boiler depend largely on the rate at which the boiler operates. For instance, in some boiler plants operating considerably below their rating, and fed with water containing as high as 30 grains of both carbonate and sulphate scale-forming salts, in a given time comparatively little scale is formed, and that quite soft; while in others, where the water contains only about 10 grains of these same salts, and the boilers are worked above rating for the same time, a considerable deposit of hard, tenacious scale is formed. The type of boiler also has a bearing on the hardness of the scale. The scale in the water-tube boiler is generally harder from the same water than that formed in the return-tubular boiler, or in the old two-flue boiler.

Softening and Purifying Water

To soften and purify a water properly means, primarily, a properly designed apparatus in which are met the requirements for complete chemical reaction. These may be summed up as follows:

1. An accurate chemical treatment, accomplished by the introduction of the proper reagents in exact quantities to react with the impurities in a definite quantity of water.

2. Thorough mixture of the reagents with the water to insure complete chemical reaction.

3. An accelerated chemical reaction, brought about by a thorough mixture of reagents and water, and by mixing the sludge of previous softening with the new finely divided precipitate. Heat will hasten the reactions, but is not essential.

4. A complete chemical reaction, brought about by a thorough mixture of the reagents with the water and by having the apparatus large enough to allow sufficient time for all the reactions to take place, and the apparatus so designed that every part of it is effective.

5. A rapid sedimentation, by having the new finely divided precipitate weighted by the sludge of previous precipitation, to cause it to settle more rapidly and perfectly.

6. A perfect clarification, by allowing time for sedimentation and final clarification by perfect filtration.

The proper softening and purification of water is, in a sense, a delicate operation, notwithstanding the large quantity of water usually handled. It is not merely a matter of lime and soda ash, but the intelligent use of the proper reagents to bring about softening and purification for a particular water supply, with neither an insufficiency of reagents nor too great an excess. A water containing 30 grains per U. S. gallon of scale-forming matter is harder than the average, yet in percentage this means only 0.05 of 1 per cent. of scale-forming impurity. Such a water completely softened should not contain more than three grains of scale-forming matter, or in percentage only 0.005 of 1 per cent. When these facts are considered, some idea is obtained of the accuracy of the treatment required for completely softening water. Of course, any reduction of the scale-forming salts is an advantage, but the maximum reduction can usually be obtained for very little extra expense with a properly designed apparatus, when such apparatus is given the necessary attention.

If a water supply contains less than four grains of lime and magnesia salts, but contains suspended matter, it should be clarified by sedimentation and filtration. If the water contains more than four grains of scale-forming salts, it should be softened and purified, that is, the reduction of the soluble impurities (not including the sodium salts, which cannot be removed) to a point where an analysis will show quantities about as follows: Volatile and organic matter, one grain; silica,

one-half grain; oxides of iron and alumina, trace; calcium carbonate, two grains; magnesium hydrate, one-half grain; but no other compounds of lime and magnesia. Suspended matter should never be more than a trace. Such a water will not form scale nor cause corrosion. It will not form scale because the amount of scale-forming salts left in solution is too small, even with concentration, to form anything but a light sludge. This sludge can be kept at a minimum by proper blowing off, and the boiler, no matter how long it is in operation, will on being opened have the appearance of having been whitewashed; the iron of the boiler can be exposed anywhere by rubbing with the finger or washing out with a good pressure. Corrosion cannot take place because the water is slightly alkaline and does not contain either corrosive acids or salts which, by dissociation or reaction, will form corrosive acids.

Catechism of Electricity

956. *What other causes are sometimes responsible for excessive heating of the armature?*

Heat may be developed in some other part of the machine and be transmitted to the armature by conduction. Then, too, the motor may be overloaded and carry too much current in the armature.

If there are one or more reversed coils on one side of the armature winding, conditions will be favorable for the development of heat, because probably there will then be a local current in addition to the operating current flowing through the reversed coils.

957. *How may a reversed armature coil causing a high temperature in the armature be located and remedied?*

Stop the motor and pass a direct current through each of the armature coils in succession. Connect the source of the testing current with adjacent commutator bars and notice the deflection of a compass needle placed over the coil undergoing test. When the reversed coil or coils are reached, the deflection will be opposite to that obtained from the other coils. In order properly to adjust matters the connections of the defective coils must be reversed.

958. *What effect has dampness upon raising the temperature of armature coils?*

If the armature coils become damp their insulation is lowered, but their temperature will not be increased.

959. *How should damp armature coils be dried?*

By passing a moderate current through the coils for a considerable length of time, or by baking the armature in an oven. In either case the drying process should be continued until the insulation resistance of the windings measures over 1 megohm.

Care must be taken in applying this remedy not to overdo it, else the shellac will melt and run and the insulation will be charred or burned.

960. *If the bearings become too warm, what may be the cause of the trouble?*

The bearings may fit too closely around the armature shaft; in a new motor they may be out of line; there may be foreign matter in the bearings.

961. *How may trouble in the bearings be tested?*

By slowly turning the armature around by hand to see if it sticks, or when shutting off the power noticing if the armature comes freely to rest.

982. *What are the remedies for troublesome bearings?*

Bearings which fit too tightly must be reamed out or scraped, or the armature shaft placed in a lathe and turned down or filed.

If the bearings are out of line with each other the motor should be shut down and the bolts holding the bearings in place partially unscrewed to allow the bearings to find their proper position. When they have done so, and the clearance between the armature and pole pieces is the same on all sides, the necessary adjustments must be made for maintaining the bearings in this position. If the motor is provided with self-alining bearings which, as their name implies, are automatic in action, and which are now commonly used on all high-grade machines, little or no trouble need be anticipated from this cause.

Dirt or other foreign matter in the bearings is liable to result from unfiltered oil being used, or when the room is not kept free from dust and dirt. A careful examination of the shaft will show whether this trouble exists, as there will be scratches on it when such foreign matter is present. To improve conditions the shaft or bearings must be taken out and cleaned.

963. *What is, perhaps, the most common of all causes for abnormal heating of the bearings?*

Deficiency of oil in the bearings is the most common of all causes of hot bearings. The deficiency may be due to a defect in the oiling rings on the shaft, to a stoppage or leak in the oil passages, or to empty oil cups. Usually this defect is easily made right, the nature of the trouble suggesting the remedy to apply.

964. *Could a very tight belt cause the pulley bearing to heat up?*

It could.

965. *How may the trouble referred to in 964 be detected and remedied?*

It may be detected by the unequal temperatures of the commutator and pulley bearings, the latter being the warmer. If the belt has not been run tight very long, the bearing will probably not have become worn sufficiently to require renewing, but in any case the tension of the belt should be lessened either by employing larger pulleys and a lighter belt or by decreasing the load on the motor.

966. *If the bearings are very warm and the armature shaft turns more easily at one point of a revolution than at another, what is probably wrong?*

The armature shaft is probably bent.

967. *What is the remedy for a bent armature shaft?*

The easiest, cheapest and, in fact, the only satisfactory way to correct this trouble is to replace the defective shaft with a new one properly turned.

968. *Are there any other shaft troubles that may produce hot bearings?*

Yes, the shaft may not have sufficient end play or it may be cut or roughened.

969. *Why is end play of the shaft necessary to keep the temperature of the bearings low?*

If there be no end play, or free movement back and forth, of the armature shaft in the bearings while the motor is in operation, the collar, shoulder, or pulley on the shaft is apt to press continually against the bearings and cause them to become heated.

970. *What should be done to correct end-play trouble?*

If, upon pressing a stick against the end of the armature shaft while in motion, there is a tendency for the shoulder or the collar on the shaft to come in contact with the bearing, a slight change in the line-up of the belt may improve matters. It may, however, be necessary to file the contact surface of the bearing or change the position of the pulley or collar along the shaft to secure satisfactory results.

971. *In case the shaft is cut or roughened, what should be done?*

The shaft should be placed in a lathe and filed or turned smooth. Care must be taken, however, not to remove more metal than is absolutely necessary, else the bearings will not fit and they will have to be renewed. In any case it is necessary to have them perfectly smooth before the repaired shaft is placed in position.

972. *Is a bearing liable to become hot by conduction of heat from some other part of the motor?*

It is. If the bearing on the commutator side of the machine is becoming heated from no apparent cause, an inspection of the commutator and armature should be made; or if the bearing on the pulley side of the machine is hot, the pulley may be suspected. When it is found that some part has a higher temperature than the bearing on that side of the motor, the proper remedy applied to the defective part will indirectly lower the temperature of the heated bearing.

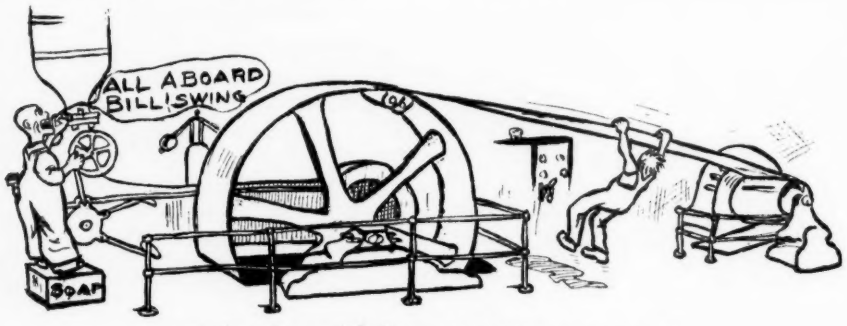
Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Extraneous Supervision of Power Plants

I have noticed with interest the matter appearing in recent issues under the above caption. I observe that the only difference between the article appearing over the name of P. R. Moses, in the issue of January 19, and the circular, a copy of which was printed two weeks previously, is that the former is addressed to the engineers, while the last was addressed to the employer. In effect the matter stands just this way: Mr. Moses cannot deny but that the circular in question had for its obvious object the undermining of the engineer's position in the esteem and confidence of the employer. If it is accepted seriously at all by those to whom it is addressed, it could possibly have no other meaning, and if given full credit, it could not fail in that effect.



HOW "BILL" AND "JIM" GET THE ENGINE OFF CENTER

In order to retain the good will of the engineers, Mr. Moses has endeavored to do that which is very difficult of accomplishment when dealing with men of intelligence. He first undertook to rob the engineer of his standing with the employer, assuming, it would seem, that this was the surest way of securing it for himself and his company. In order to get business for his concern he has assailed the engineer as the one most in his way, and since he has been caught in the act, and realizes that he has "stirred up a hornets' nest," he adopts the idea of patting the engineer on the back with a wink, and in effect saying aside, "I didn't mean it."

In his letter he virtually admits that neither he nor his company can do anything except through the engineer. That is so, but it is also a fact that the best engineers prefer to work under conditions where they will get credit for what they do, rather than where they will see it go to others. It is a virtual admission that all the advantage that the supervision company can offer over the engineer is that it can by concentration of purchases secure lower prices on supplies. What he can save in a plant of moderate capacity in this manner would not pay for the time the employer would have to spend in consultation with the representatives of the company.

Besides that, let us consider this matter of graft. This is the excuse put forward more strongly than any other for the existence of this company. This is a rather ugly compliment, but Mr. Moses began it and if, like the boomerang, it recoils and strikes him, he can blame only himself. He can also gain wisdom from the experience and hereafter use better judgment in distributing his circulars, so that they may not fall in places where they may cause him the embarrassment incident to an endeavor to defend the indefensible.

Who would have the greater temptation to graft, the man who has the selection of supplies for one concern, or one who has the same privilege with many? Is Mr. Moses so simon pure that he can withstand unspotted and unsullied tenfold, nay a hundredfold greater temptations than can we poor engineers? After all, we poor weak ones, who are incapable of dealing rightly with a case of itching palm, should rejoice that one has come forth and announced himself as willing to take from us this awful burden of temptation. If I were a grafter, I would endeavor to start an engineering supervision company of my own. I can see no shorter cut to successful and remunerative grafting. What is the use of fooling along with a few paltry quarters and fifty-cent pieces in one plant, when we can get in the supervising business so easily and have a neat income right along? Pshaw!

Grafting arises from certain causes, opportunity and a desire to get money faster than it can be secured in a legitimate way. The result of these causes will depend upon two things, the character of the man and the greatness of the opportunity to graft. When one man accuses a great number of a thing like this he is, to say the least, straining a point. Can any one man assume that he is so much better than so many others, that he is beyond temptation? And yet, business will come to this concern, as "a sucker is born every minute."

The capable engineer will get the results, but without him the engineering suvervision company cannot. The engineers who belong to the result-getting class will not work under conditions where they are obliterated. Hence the men who can get results will get out about as fast as the engineering supervision company gets in.

WILLIAM WESTERFIELD.

Lincoln, Neb.

Improving Firemen's Conditions

I read with interest the letter by W. Auld, on page 168 of the January 19 number, referring to the conditions under which firemen have to work. Firemen can improve their condition themselves if they would go at it in the right manner, but the engineers would do well to assist them. No one can do more for the engineer than the firemen, and for this reason the engineer should not be afraid to stand by his firemen. Large-minded men, and the majority of employers are large minded, like to see character in their engineers, and instead of weakening his position by standing by his firemen an engineer will strengthen it.

The firemen are not alone, however, in failing to have all that they should have in the way of conveniences in the power plant. I have known many good-sized plants where the chief engineers had no conveniences. Conditions will become better only as the importance of the operating force becomes better known and recognized by the owners. This will come through the efforts of the men themselves by bringing their work and efforts to the attention of their employers.

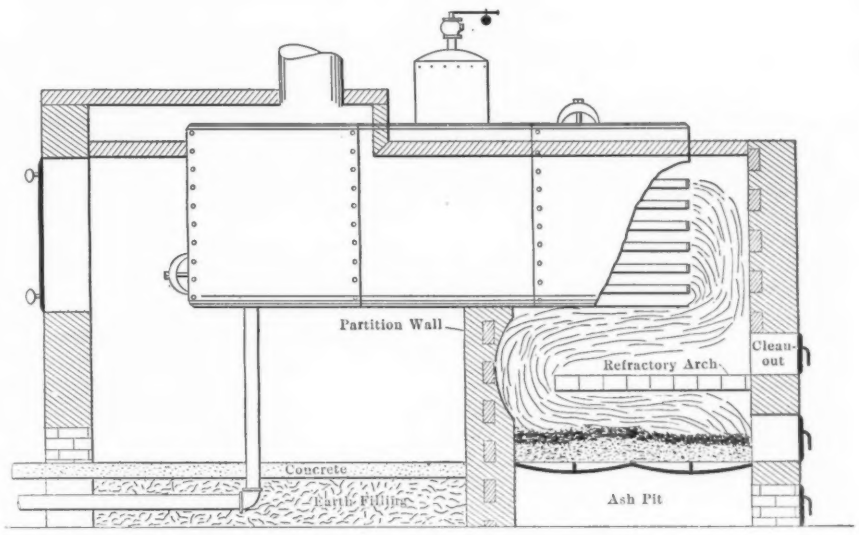
WILLIAM WESTERFIELD.

Lincoln, Neb.

An Improved Boiler Setting

The accompanying sketch shows what, in my opinion, would be an improvement on Mr. Kirlin's boiler setting, illustrated in a comparatively recent issue.

Instead of placing the fire doors on the side of the boiler, I would put them in front, where they belong, and construct a fire arch, as shown, to produce proper combustion and a practically smokeless furnace.



BOILER SETTING PROPOSED BY MR. GARTMANN

FRANK GARTMANN.

Sheboygan, Wis.

Series Circuit Supplied from Constant Potential Circuit

In one of your recent numbers you published my wiring diagram and asked the question, "Would there be any decrease in the current taken by the regulators and step-up transformer," after tungsten lamps had replaced the carbon-filament lamps?

Of the several who have made replies to the article, none has given the facts just as they have taken place since the system was changed from the carbon to the tungsten lamps. As this has been a question of some interest, particular attention has been paid to the reading of the meters during and since the change, and I will relate the facts as they have happened since the change was started.

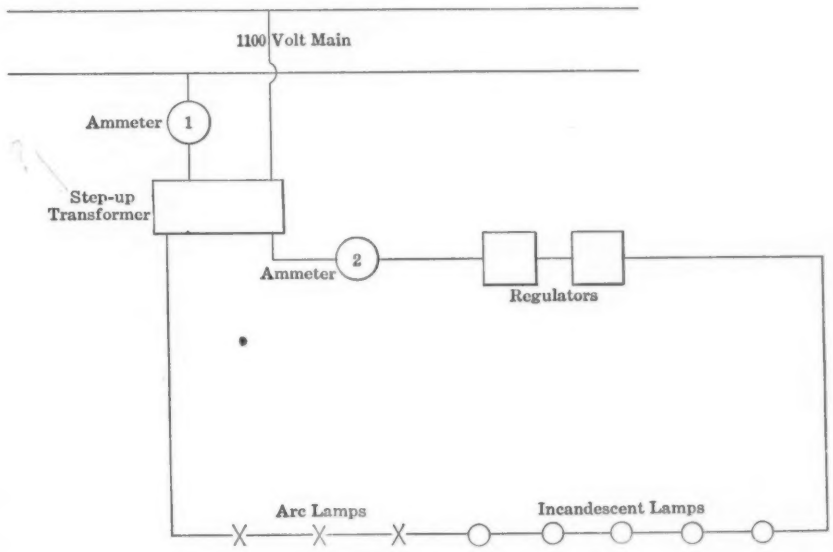
As stated in the former letter, there were 10 inclosed arcs and 80 carbon-filament lamps in series and operated from two 25-light regulators in series (connected together mechanically) and a step-up transformer with the secondary delivering 3900 volts. The connections were made as shown in the accompanying sketch. The ammeter connected in the primary line to transformer (No. 1) registered 20 amperes and the regulators were supplied with two extra weights in order to keep the current in the series circuit at the desired value, 5.5 amperes, when the carbon-filament lamps were in use. These were displaced a few at a time (from three to ten a day) by the tungsten lamps and the primary ammeter registered a little less after each change was made. When about 90 per cent. of the old lamps had been replaced with the new ones it was necessary to add six extra weights to the regulators in order to keep the current at its proper value, and the ammeter in the primary circuit registered only about 16 amperes.

Now another difficulty was encountered. The 10 arc lamps acted as if they were not supplied with enough current to energize the magnets and the carbons burned to a point, as though the globes leaked air; consequently the lamps would not give their rated candle power. This difficulty was overcome by simply changing the secondary connections on the step-up transformer (this transformer is supplied with six secondary leads and connections can be made to give any of the following voltages: 4500, 4200, 3900, 3600, 3300, 3000, 2700, 2400, 1800, 1200, 600, 300). The connections were changed from the 3900-volt connection to the 1800-volt, but this was found to be too low to give the desired current of 5.5 amperes, so the 2400-volt connection was tried and with two extra weights on the regulators it was found to be just right. After this change was made the arc lamps burned as well as they ever did, giving a nice clear light, and the primary ammeter now registers from 8 to 10 amperes.

Can anyone explain why the arcs acted so mysteriously when the transformer was connected to give the higher voltage? The candle power of the incandescent lamps was not visibly affected.

D. W. GROVE.

Covington, Va.



MR. GROVE'S WIRING DIAGRAM

Knock in the Engine

I am operating a plant containing an 18x48-inch simple Corliss engine, running at 90 revolutions per minute, and belted to an alternator. The engine has a peculiar sort of knock as the crank passes the centers. It can be heard more distinctly on the outer than on the inner stroke and gives a clicking sound that is heard for three or four revolutions and then stops for about the same number.

Everybody in the plant has tried to locate the knock, but without success. The end bearing of the crank shaft runs warm, but not hot, and the knock does not appear to be in it. All other bearings seem to be all right and run cool.

J. W. BRYAN.

Goldsboro, N. C.

Gas Engine Valve and Ignition Timing

My experience with gas engines has led me to different conclusions from those expressed by Mr. Hollman, on page 167 of the January 19 issue. He says, near the close of his letter: "Thus the inlet valve should close when the piston has started back a certain distance, and the exhaust should open when the piston is at a certain distance from the end of its stroke."

From the language used, the four-stroke-cycle engine is being considered, in which case the theory advanced seems to be erroneous. In order to grasp the operating sequence of this type of engine it should be borne in mind that we are dealing with a gas pump during the exhaust and suction strokes, and as any adjustment that advances or retards the time of opening a valve must produce the same change in the time of closing, is it not obvious that something less than a cylinderful of mixture will be trapped whenever the valves are closed at any other time than when the crank is exactly on the center?

The fact that the gas mixture is burned in the cylinder has nothing whatever to do with the question of proper valve setting, in which case is it not apparent that in order to get the best results from our "gas pump" we must open and close the valves on the centers just as all other pumps do, or should?

The efficiency of a gas engine depends on its getting a cylinderful of a proper mixture of gas and air, compressing it to the best point and then firing at the proper time relative to the crank or piston position. All of these questions except the first one are best determined by local conditions, but the importance of starting out with a *cylinderful* of mixture is hardly open to discussion, and the only way to secure that result is to open and close the valves exactly on the dead-center points.

If the gas-engine operator will vary the quality of the mixture and the compression and the time of igniting, it will be found that the efficiency of the engine varies with these changes and that a compromise or happy medium may be arrived at where, for instance, the spark may be advanced to a point giving the highest initial pressure, the best burning conditions, etc., without going so far that the initial pressure or compression is high enough not only to overcome the inertia of the moving parts, but actually to exert pressure on the wrong side of the crank pin. In one case an engine using natural gas, compressing to 75 pounds absolute and running at 250 revolutions per minute, did its best work when the spark was set 22 degrees ahead of the dead point; that is, the crank lacked 22 degrees of having reached the dead center when the charge was ignited.

E. G. Tilden.

Downers Grove, Ill.

Keeping Motor Records on Index Cards

In large establishments where there are many motors in use, some system of keeping records is desirable to enable the man in charge to ascertain quickly any desired data about the equipment under his charge. The best method available, within the writer's knowledge, is the card index. The accompanying engravings are reproductions of the two sides of a card taken from the file of the plant in the writer's charge. In the system used here, alternating-current motors are numbered below 1000 and direct-current motors above 1000; the cards for alternating-current motors are salmon-colored and the others light blue. A group of numbers is reserved for each size of motor (for instance, 200 to 250 for 3-horsepower motors) and a guide card bearing this size on an extended tab is inserted between the groups of cards to facilitate the location of any card desired.

When a new motor is purchased a card is filled out with all the information except the rewinding data, and placed in the index, where it remains until the motor is brought to the shop for repairs. The card is then taken from the index file and the necessary winding data entered on it, an account of the repairs being also entered, but on the back, and the card returned to the file.

MOTOR NO. 387

ALTERNATING CURRENT

MAKE	Westinghouse	STATOR SLOTS	72	PULLEY	8" dia. x 4"	STARTER	Oil immersed
TYPE	"C"	ROTOR SLOTS	47	SHAFT	1 5/8"	FUSE BLOCK	Nall Code
H. P.	5	NO. OF COILS	72	BEARINGS	1 3/4"	START FUSES	30
SPEED	1120	THROW	1-9	ROTATION	Right hand	RUN FUSES	10
VOLTS	440	SIZE OF WIRE	14	ON PULLEY END	with	H P LIGHT	1.4
PHASE	2	TURNS PER LAYER	7		crossed belt	H P LOADED	6.3
CYCLES	60	LAYERS PER COIL	2			DATE	12/27/08
AMPS. PER P	6.5	HAND	36 R. 36 L.				
SERIAL NO	49368	COILS PER GROUP	6	CONTROLLER	None	LOCATION	Emery wheel West bay Sage dept
FRAME	Open						
POLES	6						

(REMARKS OVER)

FIG. 1. FRONT SIDE OF A MOTOR-DATA INDEX CARD

Where temporary repairs are necessary they are noted on the back of the card, and the card is taken from its regular place in the index file and placed back of an index card marked "Hospital," so that the temporary nature of the repairs will be kept in mind and permanent repairs made as soon as possible.

Bearings rebabbited
7 Coils replaced
Broken Oil ring repaired
} JAN 13 1909

FIG. 2. REAR SIDE OF A MOTOR-DATA INDEX CARD

This card system has proved a great convenience to the writer; it makes a complete record of every motor in the plant instantly available. This letter is written with the hope that the system may prove of value to others similarly situated.

R. H. Fenkhausen.

San Francisco, Cal.

What Caused the Valve to Break ?

Following is an account of an accident that has twice happened since installing a drip-return pump and new feed line. The first accident was the cracking of a flange at the end of the feed line and the breaking of the body of a 6-inch valve. The second time a joint blew out at a flanged ell and the bonnet of the stop valve cracked.

The discharge from the drip pump enters the feed line at about its center. The feed line is of 6-inch pipe, 150 feet long, and feeds water to twenty 318-horsepower water-tube boilers. Four duplex pumps, 10 and 6 by 12-inch, take water from two open heaters at a temperature of 190 degrees Fahrenheit. This feed line is supplied with a 4-inch release valve, set at 140 pounds. It is well braced and has an expansion bend in it.

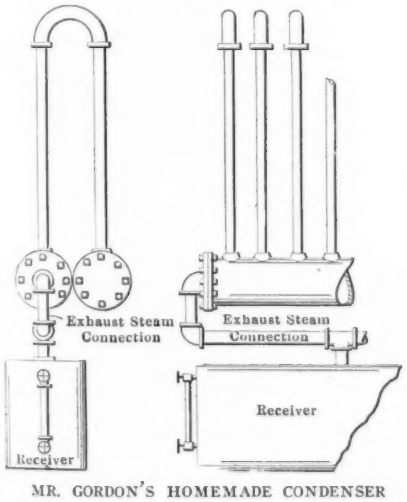
The drip pump takes its water from six separators, large and small, situated on the main steam lines leading to the engines. The steam pressure is 115 pounds, and the pump is located 25 feet below the feed line. At the time when the accidents happened there were twelve boilers in operation and the head fireman reported everything as usual. All fittings and pipe are extra-heavy.

FRANK J. ALDRED.

New Aberdeen, C. B.

Homemade Condenser

The accompanying sketch represents a condenser such as may help Mr. Casper out. The return pipes are fitted to the



MR. GORDON'S HOMEMADE CONDENSER

header, with a connection for the exhaust steam, and return to the side of the bottom piece, which shows the connection for the condensed water coming out of each end and flowing to the receiver, from which it may be handled by a pump.

The return pipes may be made any length, depending on the size of condenser required. The condenser is submerged in a tank, the water running in and out all the time, so as to furnish cool water for the condenser.

THOMAS GORDON.

Chemawa, Ore.

Connecting Steam Boilers

Referring to the letters by Frank Eastman and M. Kennett, in the December 15 number, I would say that both describe a very faulty method of connecting up steam boilers, which is more or less in vogue.

It seems to be the idea of some engineers that the valves must be placed as close as possible to the boiler. This practice is wrong, as it leaves more or less

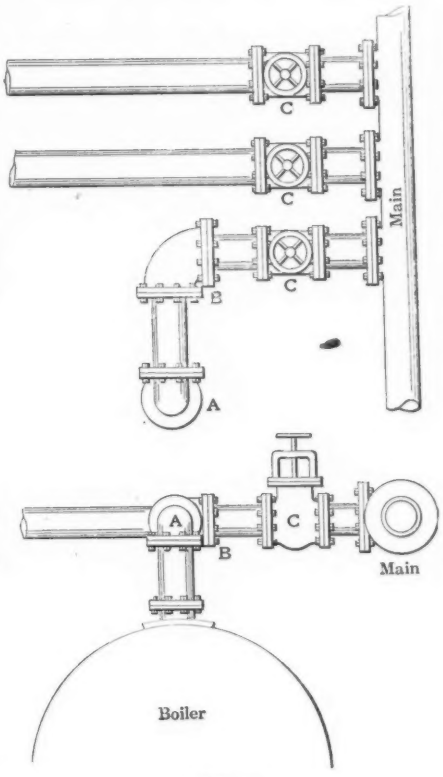


FIG. 1

pipe in which there is no circulation when the boiler is idle, causing condensation of steam, which is apt to form a dangerous slug when the boiler is put in operation.

A better plan is to put the stop valve as close to the header or point of distribution as possible, as there will presumably be steam in the header at all times when one or more boilers may be idle.

A still better plan is to put a nonreturn valve or automatic stop valve, working both ways, near the header and a plain valve near the boiler. This is according to the latest practice for high-pressure work. The valves, however, should be kept at the highest point, so that there will be no chance for water of condensation to accumulate.

Referring to Mr. Eastman's arrangement, if stop valves only were used, I should recommend placing them at *C*, Fig. 1, herewith, or if both stop valves and nonreturn valve were used, I should place the nonreturn valve at *C*, and the stop valves at either *A* or *B*, but in no case on the vertical pipe down near the boiler.

In reference to Mr. Kennett's plan, the nonreturn valves should be placed at *B*, Fig. 2, herewith, and the stop valve at *A*.

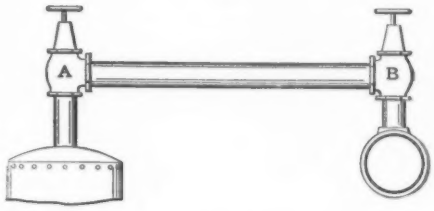


FIG. 2

Regarding the matter of draining headers, it is not a good idea to drain back into a boiler, where a number of boilers are used, as each boiler should be positively and completely cut out by one valve only. This lessens the chance of turning steam onto a man who might be inside the boiler for cleaning or inspection. A good, reliable steam trap will drain a header very satisfactorily. In some cases headers are drained satisfactorily by using steam to run the boiler-feed pumps from the bottom of the header.

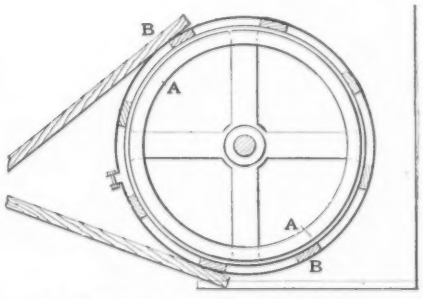
G. REICHARD.

Los Angeles, Cal.

Cooling a Prony Brake Wheel

In the mechanical laboratory of a certain school there is a small slide-valve engine, used for testing the brake horsepower developed at different valve settings.

For a long time I had trouble on account of the heat generated by the friction of the brake on the surface of the



FOR COOLING A PRONY BRAKE WHEEL

wheel. The plan used to overcome this difficulty was as follows: I had some 3-inch angle iron bent in a circle, with a flat face out, and made to fit exactly the inside of the wheel. After making two of these I bolted one on each side of the wheel, with a flat face outside, so as to form a 3-inch flange all around the inside

of the wheel, as shown at *A* in the sketch. Water is kept in the trough thus formed, and when the wheel is revolved all parts of the inside face of the wheel are bathed, thus keeping the temperature from getting too high for some time. At *B* is shown the brake as it is used on the pulley wheel of an engine.

E. S. RODNEY.

Baton Rouge, La.

Determination of the Calorific Value of Low-grade Fuel

In reading F. H. Neely's very interesting and valuable article in a recent number of POWER, I was reminded of a modification (if it may be called such) of the well-known Dulong formula for calculating the heat value of a coal, adapting it to lignite and peat. The Dulong formula given by the American Society of Mechanical Engineers in its "Rules for Conducting Boiler Trials" is as follows:

$$14{,}600\,C + 62{,}000\left\{H - \frac{O}{8}\right\} + 4000\,S,$$

in which *C*, *H*, *O* and *S* are the percentages of carbon, hydrogen, oxygen and sulphur in the coal, by the true analysis. The number 14,600 represents the number of B.t.u. in one pound of carbon; 62,000 that for hydrogen and 4000 for sulphur. The ratio $\frac{O}{8}$ takes into account the oxygen which would combine with the hydrogen to form moisture and is, therefore, subtracted from the total hydrogen.

For those unfamiliar with this formula, the following analysis will clearly show its use: Carbon, 74.79 per cent.; hydrogen, 4.98 per cent.; oxygen, 6.42 per cent.; nitrogen, 1.20 per cent.; sulphur, 3.24 per cent.; moisture, 1.55 per cent.; ash, 7.82 per cent.

Substituting, we get:

$$14{,}600 \times 0.7479 + 62{,}000$$

$$\left\{0.0498 - \frac{0.0642}{8}\right\}$$

$$+ 4000 \times 0.0324 = 13{,}650\ B.t.u.$$

A calorimeter test showed 13,480 B.t.u. for this coal.

To apply the Dulong formula to lignite or peat, instead of taking the true analysis, use the analysis corrected for moisture, and to this result add the heat carried away by the moisture in the fuel.

As an illustration, take the North Dakota lignite given in a bulletin of the United States Geological Survey: Hydrogen, 5.22 per cent.; carbon, 52.66 per cent.; nitrogen, 0.71 per cent.; oxygen, 27.15 per cent.; sulphur, 2.02 per cent.; ash, 12.24 per cent. The moisture equals 15.42 per cent.

Substituting in the Dulong formula, the following is obtained:

$$14{,}600 \times 0.5266 + 62{,}000$$

$$\left\{0.0522 - \frac{0.2715}{8}\right\}$$

$$+ 4000 \times 0.0071 = 8862.9\ B.t.u.,$$

the heat carried away by the moisture.

Assuming the lignite to be at 62 degrees Fahrenheit when fired and the gases to be at 420 degrees Fahrenheit on entering the breeching, we have 150 B.t.u. to head one pound of water from 62 to 212 degrees Fahrenheit; 966 B.t.u. to evaporate one pound of water from 212 degrees Fahrenheit to steam at 212 degrees Fahrenheit; 210 B.t.u. to raise the steam to 420 degrees Fahrenheit; and 1324 B.t.u. total heat carried away by one pound of water.

$$1324\ \text{B.t.u.} \times 0.1542 = 204\ B.t.u.$$

Adding the two values gives

$$8862.9 + 204 = 9066.9\ B.t.u.$$

per pound of lignite. The fuel actually gave in the calorimeter 9061 B.t.u.

The assumption as to fuel and breeching temperatures is very close to average practice and can vary several degrees and not make an appreciable difference in the results.

I discovered this relation while preparing a course of lectures on "Fuel Technology," which was given at the University of Wisconsin in 1906, and have applied this modification to a large number of lignites and peats and find it always gives very close results. I have never applied it to wood, but believe it would work equally well.

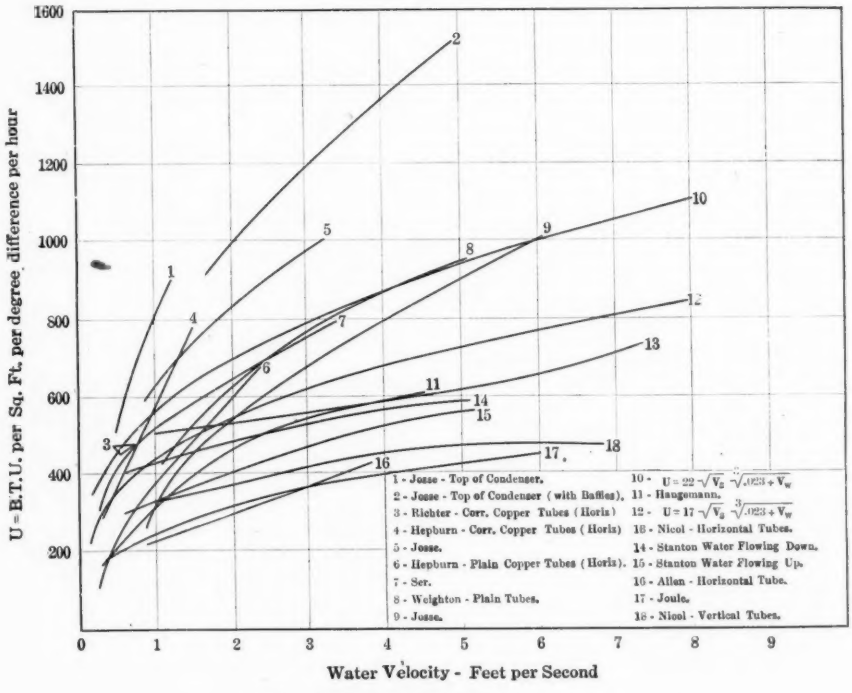
W. A. RICHARDS.

Chicago, Ill.

Surface Condensation for Steam Turbines

I note with pleasure that you have published an abstract of Professor Josse's paper on surface condensers, referred to by Mr. Mueller in his criticism of my article on the same subject. Professor Josse's paper is of great value, supplementing as it does the work of Weighton and Morison. The curves given in Fig. 2, page 234 of the February 2 number, are particularly interesting and I have plotted them on the set of curves you reproduced before. The curves representing the value of *U* when "baffle strips" were used in the tubes are not applicable to ordinary condenser conditions, as the increase of head and power for the circulating pumps must have been quite marked. The other curves are even better than Weighton's and more nearly agree with the theoretical formula, although with a slightly different constant. It is not strange that Josse should have fallen into the error of considering that *U* varied with the square root of the velocity of the cooling water when it is understood that he used the metric system and all his velocities are near one meter per second; the differences between the square root and the cube root at that point would not probably be larger than the error in the value of *U*. With the English system, however, the numerical values of the velocity are higher and the differences much more marked. It will be seen that the values given by Ser conform more nearly to the cube-root curve than to the square-root curve.

It is also interesting to learn that Pro-



HEAT TRANSFERENCE THROUGH TUBES

fessor Josse has developed the formula for surface

$$S = \frac{Q}{U} \log_{\varepsilon} \frac{t_s - t_e}{t_s - t},$$

which has been in use in this country for some time, and found it better to represent actual conditions than Weiss' old formulas so often quoted in foreign works. Hermann Wilda in his "Marine Engineering" (Hanover, 1906), gave a formula similar in form, but the further possible simplification was apparently not seen.

The experiments showing the transmission of heat to air are interesting and of value. Josse's air pump is known in this country as the Bailley pump, and has been installed in a number of naval vessels. The only new thing in it is the additional air inlet above the piston, making the pump somewhat similar in action to the new Bodmer pump of the Allis-Chalmers Company.

Professor Josse's remarks on the contraflow principle are very well taken and represent American practice fairly well, except that we find it usually advisable to use the contraflow principle. The fact that every condenser tube must necessarily be filled with water at all times with this system is sufficient reason for its adoption.

GEORGE H. ORROK.

New York City.

Babbitting a Main Bearing

On one occasion when babbitting a main bearing of a medium-sized engine, I had trouble with seams in the babbitt.

At first it was thought the babbitt would have to be taken out and repoured. The following idea was carried out, however, and its success was well worth the small amount of trouble it caused:

Where the seam showed, the metal seemed to have run smoothly enough, but close to the edge of the box the outer edge was loose. A 7/16-inch drill was used to bore a string of holes down the seam, so as to catch a portion of the solid and loose metal. The holes were quite close together so there were very thin bridges between. After melting the babbitt as much as it would stand, a hot iron was used on the string of holes, melting down the bridges and thoroughly heating the metal. While this was being done the hot babbitt was poured in, forming the whole in one solid piece.

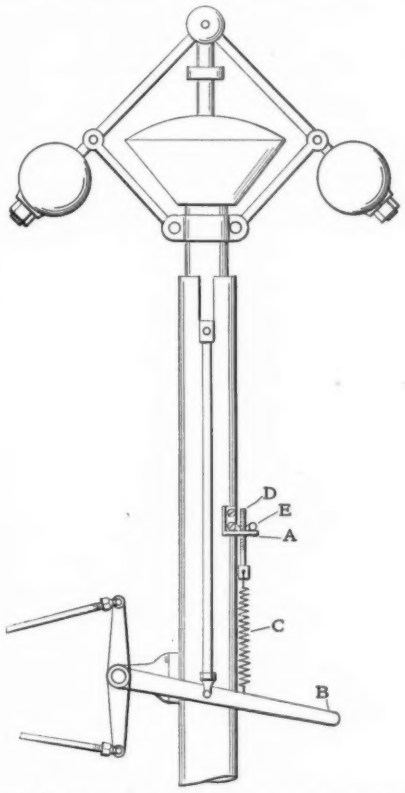
It is a good plan, when using the iron to warm the metal, to put in a little powdered rosin. These seams, flaws and holes, so annoying in babbitting, are mostly caused by not having the shaft, arbor, or whatever is used to cast around, hot enough. Then, too, it is sometimes difficult to get the metal in the bearing hot, but this should be done at all odds. A good material for preventing the metal from leaking while pouring is composed of flour and common engine oil, mixed to a dough. This is far better than clay or such material, as the moisture causes steam and blowouts are likely to occur.

JOSEPH W. LITTLE.

Fruitland, Wash.

Prevents the Governor Dropping

The accompanying sketch is of an attachment we recently installed on the governor of a 350-horsepower Corliss engine driving a two-phase generator. For some time we had been troubled with the governor dropping to its lowest position when the engine was carrying full load or



DEVICE TO PREVENT THE GOVERNOR DROPPING

was slightly overloaded and the steam was a little low.

This engine was designed to run at 104 revolutions per minute and in case of a heavy load would lose from six to eight revolutions per minute, thereby allowing the governor to drop, causing the safety device to prevent the latch catching the valve, thus stopping the engine. To obviate this difficulty we bolted an angle iron *A* to the governor post with two ⅜-inch machine screws, and through the outer end of the angle iron drilled a ⅜-inch hole. Through the governor lever *B*, and directly in line with the ⅜-inch hole in the angle iron, a ⅛-inch hole was drilled. In this hole was fastened the lower end of a ¼-inch steel coil spring *C*, and to the upper end was fastened a ⅜-inch bolt *D*, extending through the ⅜-inch hole in the angle iron. A butterfly nut *E* was placed on the upper end of the bolt.

Increasing the tension of the spring prevents the governor from dropping quickly under variable steam pressure, but the tension must be varied with different loads. This spring, however, will not prevent the governor's dropping and cutting the steam off in case the governor belt should break or fly off for any reason.

D. M. GROVE.

Covington, Va.

The Sense of Proportion

Most inventors lack that sense of proportion which helps a man to keep himself from looking the ass so many of us really are. The same inventions are constantly coming up to the top, but there is a new inventor and a new set of promoters, a new man with a fur coat. I wouldn't give a red cent for any invention unless at least one man, in the miscellaneous crowd that attends at the demonstration, wears a fur coat, or at least has fur collar and cuffs to his overcoat. He adds that one touch that makes the inventor so sure he has fallen among honorable city financial men of standing. At one time it is a rotary engine. Now, of late years, there has sprung up a new development of rotary engines. None of your common racheting quick-sliding steam-trapping sliding-door abutment valves, but genuinely artful and ingenious mechanical motions which get behind the steam and make it labor expansively for the benefit of the promoter. Some of them are really most ingenious, and within limits there are now rotary engines that will work very well. And the hopeful inventor measures up his little 10-horse buzzer, length, breadth and hight, and in a few minutes he has shown you that put into the "Mauretania" it would knock spots off the present steam plant very completely.

Most of the men connected with these affairs are busy buying reports from consultants, for blocks of shares and promises. They come to me often enough with little things that are good enough as little things, but all of them want reports saying that the little thing only needs multiplying by 10,000 and it will drive the "Lusitania." A tear comes into their eye when I give them a report of facts and warn them that Lucy is not for them.

Then there is the steam boiler which, "by a peculiar adaptation of a well known but little recognized law to the evaporation of certain liquids has disclosed unsuspected merits in a quite novel cycle of operations from which great results may confidently be anticipated." At least, this sentence explains the sort of impression that is left on my mind by reading some of the prospectuses. It makes me

think of hiring myself out to some honorable promoter as a writer of prospectus catch sentences. Why should such a gift of language lie fallow? I think it a beautiful sentence. As a rule if one succumbs to the temptation to go and see the wonderful invention at work there is much to be learned.

This is a great city. I have been in it for twenty years and before we had so many tubes it was often better to walk when one was in a hurry, better even than a cab, for a cab always runs its head into a block and one is held ten minutes for the block to melt away. Of course, if you are a promoter you take a cab anyhow. Well, as I was saying, I have done much walking to save time, and as I carried the map in my head and a compass in my pocket, I could usually steer a direct course from point to point. Needless to say I thereby became acquainted with strange labyrinths. But for out-of-the-way concealed curiosities there is nothing so weird as the dens into which one penetrates in finding the home of the invention which is to revolutionize all our existing ideas and wreck so many prosperous manufacturers who have but little longer to palm their obsolete productions on a too confiding public.

It reminds me of when I was a child and had a toy consisting of a house and a sort of turntable with animals on it. The table revolved and a constant stream of animals went into what I suppose must have been a model ark. One hid from one's understanding the fact that the same animals recurred like a decimal; and so now when childhood No. 1 has gone away into the dawn of nothing the old turntable turns again, but in place of animals it carries rotary engines, and boilers and new types of all manner of furnaces and smoke devices, which are usually perfect but for the one essential without which none can be. There are water circulators and occasionally a perpetual-motion device cleverly cloaking its features behind some such beautiful veil of words as I have outlined.

A story is told of an absent-minded but learned man who bumped into a cow and raised his hat in apology. The true facts gradually sank into his mind and in a bit he ran down a lady. But now he was fully aware of the enormity of his previous folly and rapped out: "Is that you again, you brute?" And so with the stream of epoch-making inventions. You don't quite know whether to raise the hat to them or treat them as brutes, and the worst is that when the real lady invention trips along she receives the welcome of a brute, and unless the idealist inventor is of tougher material than most of his kind he usually gets no better treatment by the world than the inventor of the perpetual-motion crankiness.

W. H. Booth.

London, Eng.

Leak in Belt Driven Air Compressor

In the plant where I am employed we have a small belt-driven air compressor, supplying air at 80 pounds pressure to molding machines. The capacity of the compressor is about 35 cubic feet per minute. It has an automatic governing device which holds the pressure at any predetermined point within its capacity.

While on my vacation this machine refused to deliver the quantity of air needed and no amount of coaxing on the part of my assistant, who was in charge, would get it to do so. A machinist was called in, who stripped the machine and on using his caliper found the cylinder to be out of round about 0.005 or 0.006 of an inch. This he claimed was the cause of the trouble, and wanted the cylinder bored and a new piston fitted.

Upon my return a few days later I overhauled the machine, but could find no reason for the failure to do the work, as the cylinder, piston and rings were in good condition. I concluded that air was being wasted somewhere about the plant, and looked for leaks for several days. At times the pressure would go to 65 or 70 pounds and at others down to 25 pounds. Finally a search resulted in locating the trouble. It was in a beautifully arranged ventilating system using a sort of spray jet, having a head with nine 1/16-inch holes and was supplied by a 3/8-inch pipe with a valve to regulate the amount of draft. This device was not used all the time, which accounts for the fact that at times we could get our air pressure about up to normal.

The ventilating scheme was put in without my knowledge, or I should have known that it was the cause of the many hard names I had to stand for from the foundry foreman. The moral I have learned is, in case of failure of supply from no visible cause look for leaks. Also look for the inventive chap with a club.

O. M. Dow.

Lowell, Mass.

Drilling a Tank

In W. H. Wakeman's article on page 1085, Volume 29, he describes how he drilled the tank for his oil gage, using a board cut out as at *A*, Fig. 1.

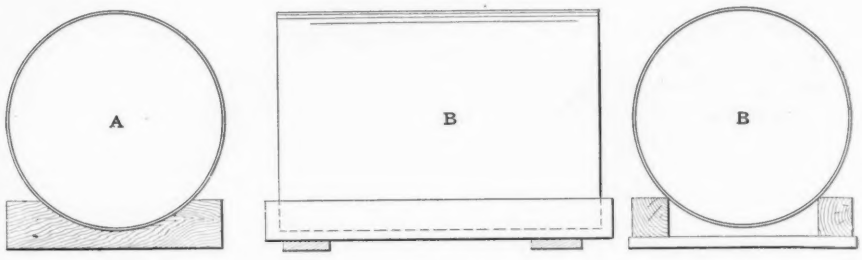


FIG. 1

This method is all right, but it is usually easier to take two pieces of 2x4 or 4x4 stock and fasten them together by nailing two strips or boards across the bottoms, as at *B*. In this way any size of cylinder can be fitted in a minute, and a bandsaw is not always available to circle out with.

If the cylinder or pipe has flanges on each end, the side pieces should be cut so as to go between them. Sometimes where the cylinder is long and the drill-press platen small, it is better to nail several pieces on the bottom.

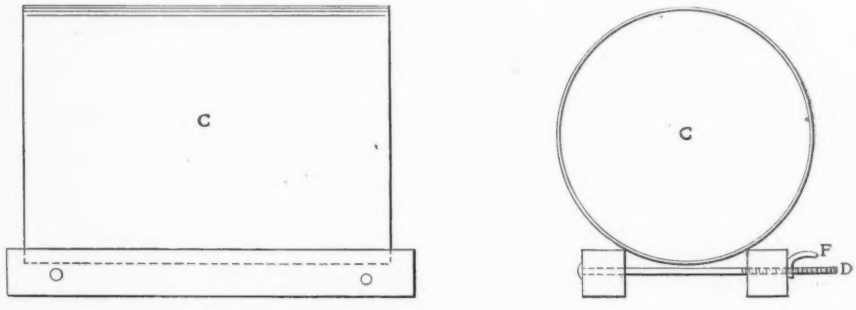


FIG. 2

An adjustable rig used in the repair department of a railroad shop is shown at *C*, Fig. 2. The 4x4-inch side pieces are conected by long bolts *D*, which have a rather loose-fitting "crank nut" *F*. These adjustable supports are not only handy for holding various sizes, but anything placed on them can be quickly leveled by working only one of the "crank nuts."

Ethan Viall.

Decatur, Ill.

Edwin Reynolds Dies After a Long Illness

Contemporary of Corliss and Superintendent of the Corliss and Allis-Chalmers Shops Passes Away at Milwaukee; Sketch of His Career

Edwin Reynolds died at his home in Milwaukee on Friday, February 19, after a three-years' illness.

Edwin Reynolds was born March 23, 1831, at Mansfield, a little town in northeastern Connecticut. He was descended from William Reynolds, who had come from England about 200 years before and settled at Providence, R. I. His father's name was Christopher Reynolds and his mother's maiden name had been Clarissa Huntington. There was a large family, six boys and six girls, and Edwin was next to the youngest. His father, though then a farmer, had been a cloth dresser and had on his place a fulling mill run by water power, but this had not been in operation within the boy's recollection. Edwin worked on the farm and went to the district school, his last schooling being in his sixteenth year, and then a change came in his life. He had up to this time little or no knowledge of the machine shop, and nothing had turned his thoughts or inclinations in that direction. At the age of 16, Mr. Reynolds started out as a farm hand, engaging first with a neighbor for six months at $11 per month. He had worked only about a month when one day, as he was busy in the middle of a field, a man climbed over the fence and came to him. The man asked first if he was one of the Reynolds boys, and then whether he would like to learn the machinist trade. It was a new idea to him, and he had to think over it for a little while before he said that he would, but he immediately added that it would not be possible to begin just then, as he was engaged to this farmer for six months. The farmer was a reasonable man. On being consulted he said:

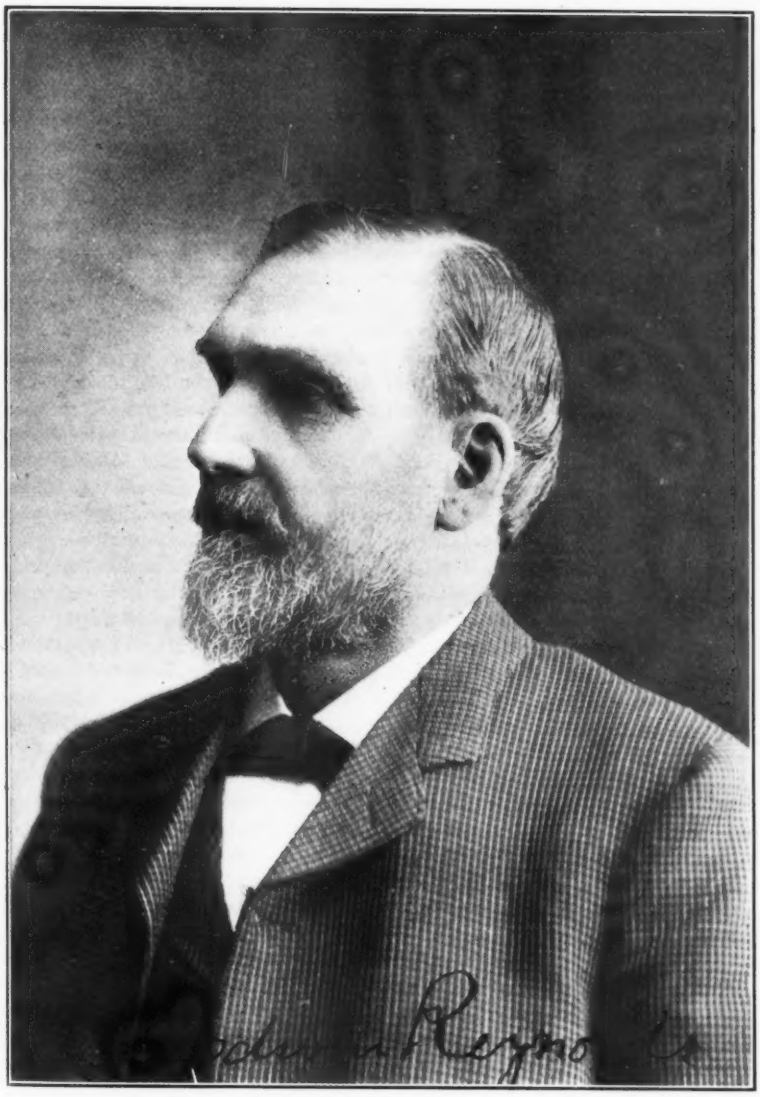
"Would you like to learn the trade, Ed?"

"I think I would," said Mr. Reynolds.

"Well, a trade is a mighty good thing to fall back on. I'll tell you what I'll do. You come and help me for a month in July and I'll let you off now."

So a three years' apprenticeship was begun with Anson P. Kinney, or Kenney, who had a general machine shop, with a specialty of sewing-silk machinery; several cards, or carding machines, also being built during Mr. Reynolds' apprenticeship. A country shop in 1847, we can well understand, was a crude affair. There was in the first place no foundry. The tools of the shop comprised one 20-inch engine lathe, one bench lathe, or, as we might now call it, a patternmaker's lathe, one vise and a circular saw. Some creditable machines were, however, turned out, and Mr. Reynolds' apprenticeship consisted largely in learning, not the trade as we understand it, but "how to do things without any appliances wherewith to do them." A memorable event of Mr. Reynolds' apprenticeship was the addition of a 16-inch lathe to the plant. Mr. Reynolds lived with his employer and their relations were more like father and son. His wages were, for the first year, $30 and his board, the next year $45 and for the last year $60.

On the completion of his apprenticeship Mr. Reynolds worked as a journeyman for a year with Smith, Winchester & Co., at South Windham, Conn., who built paper machinery, and then he went as a journeyman to the Woodruff & Beach Iron Works, at Hartford, one of the large companies at that time, which built slide-valve steam engines and general machinery. While Mr. Reynolds was working there, Mr. Wright became engineer of the works, and they began the building of the Wright engine. No concern in those days, however, built engines exclusively, and the Woodruff & Beach works, among other things, turned out a lot of stone-dressing machinery, in the building of which Mr. Reynolds soon became a gang boss, eventually taking charge of all



THE LATE EDWIN REYNOLDS

that line of work in the shop and in the erection of the machines after they were sent out. This connection continued for six or seven years, or until about 1857, when Mr. Stedman, of Stedman & Co., Aurora, Ind., who had been a classmate of Woodruff, came East looking for a superintendent, and Mr. Woodruff — as some other employers have nobly done, but as some would not have done— recommended his subordinate as precisely the man for the position, and so Mr. Reynolds went to Aurora as general superintendent. The silent partner of Stedman & Co. was a resident of Aurora—J. W. Gaff, a wealthy distiller and steamboat owner—and, with Grey and Gordon, the owner also of the Niles Tool Works. Stedman & Co. had a general machine-shop business, building also plain slide-valve engines, sawmills, farm machinery and pumps for Southern plantations. The designing of large pumps for drainage and irrigation was a promising field which Mr. Reynolds proceeded to develop. Patents of the old Andrews pump and others were offered the firm, but none showed or promised satisfactory efficiency, so Mr. Reynolds decided to design a pump, and in connection with this scheme he made some crude experiments, the results of which have been of value to him in connection with his largest and most daring work of later years.

The breaking out of the war between the States interfered so seriously with the business at Aurora that Mr. Reynolds found himself out of employment and came East, making Boston, New York and other places his quarters for the next few years. These were no more years of idleness than the others had been. He took charge of a shop in Boston for George T. McLaughlin, and besides that he was interested in the development of a number of special machines, either as designer or consulting engineer.

In 1867, Mr. Reynolds, who had become known as a manager combining technical knowledge with executive ability — then, as now, a rarity—was offered a commercial and engineering position with the Corliss Steam Engine Company, whose shops at Providence, R. I., were the largest and most important in the country, if not in the world, for the manufacture of steam engines. The Corliss plan of operations had from the first and always called for salesmen who distinctly were competent engineers. After four and a half years in this position, Mr. Reynolds was made general superintendent of the works, which position he held until 1877. He had not held the position so long without suggestions and invitations to change. His old friend, Mr. Gaff, and also Mr. Gordon, of the Niles Tool Works, tried hard to get him to take hold of that institution, offering an interest in the works on terms exceedingly favorable. Having declined this offer, the acceptance of a connection with the Reliance Works of E. P. Allis & Co., Milwaukee, Wis., may have a rather unaccountable aspect. The position held by Mr. Reynolds at Providence was then perhaps the highest in the engineering business in the United States. He went to the remotest corner of the manufacturing field, and connected himself with a firm practically unknown and in embarrassed circumstances. The firm had failed the year before; they had a ramshackle shop; the foundry, which had been fitted up for pipework, was of a piece with the rest; and, all told, only about 150 men were employed. It is scarcely probable that Mr. Reynolds foresaw what the business would so soon grow to, but he must have seen in it more or less clearly the opportunity of his life. Mr. Corliss had grown rich and dictatorial, seemed to believe that his word was law in steam engineering, and took the position, more or less pronounced, that any man who wanted the best engine must buy it of Corliss and must pay the Corliss price for it without question. In the meantime, Mr. Reynolds, as events would seem to indicate, had ideas of his own about Corliss engines and other things. He evidently believed that the original Corliss engines could be greatly simplified and improved, that he knew the way, and that the improvements, combined with correct business methods, must result in the building up of a great business. There may have been more than a little of sympathetic benevolence in it, also. Here was a concern in a bad way. Neither Mr. Allis nor his sons had engineering knowledge or ability. He could help them, assume an independent position for himself and find full employment for his teeming engineering ideas, and so he became the engineering brains of the Allis works.

It has been erroneously stated, on many occasions, that the attention of Mr. Allis was particularly attracted to Edwin Reynolds by the "Reynolds-Corliss compound engine" exhibited at the Centennial in 1876. As a matter of fact, however, this unit consisted of two simple Corliss engines compounded, and they were of the regular type built at the Providence shops. Further than for his being general superintendent of the works at the time, there is no reason particularly to identify Mr. Reynolds' name with that of the Centennial engine.

After entering upon his duties for Mr. Allis, the first and most essential thing was to place the business on a paying basis. This was done almost at once through the development of the "Reynolds-Corliss" engine, which has become a synonym for simplicity, economy and reliability, collectively expressed. The first engine was a 14x36-inch girder-frame Corliss stationary engine. It was sketched on the back of an envelop during a ride from Milwaukee to Chicago, after his first visit to the scene of what were to be his life's greatest successes. This design was not his best on general principles, but the best to build with the shop equipment at the time. This, it will be understood, was not only miserable, but there were no means at hand for the purchase of better. The first tool put into the shop after Mr. Reynolds took charge was an 8-foot boring mill, furnished by Mr. Reynolds' old friend, Mr. Gaff of the Niles Tool Works. Mr. Reynolds had to and did design the thing which it was possib'e to build in the shops as they stood, without spending a cent at first for equipment. It was necessary to compromise, not only with the machine shop, but more especially with the foundry, which was worse, and even the facilities, worst of all, for transporting the castings from the foundry to the machine shop had to be yielded to. The frame, then, was made in two parts, so it could be handled, so either right or left could be made from the same pattern, and so, in deference to the lack of skill in the foundry, the core work was reduced to a single simple core in the jaw. At a later time, when the demands of the business were growing faster than the facilities, the wrought-iron-frame engine was designed as a means of relief. The Reynolds engine of 1890 may probably be said to be the first design in which serious concessions have not been made to the facilities of construction or other imperative conditions. Mr. Reynolds' method of work has seemed to be first to make a careful study of all the conditions of the individual case, and first of all with reference to the underlying engineering principles. On these for a foundation he would work out the simplest machine possible, remembering always the possibilities of the shop as well as the idealities of the drafting room. This has usually practically ended the matter. Once the design has been decided upon, he has been prepared to fight for it, and usually successfully, and a very large part of the Allis business has been obtained, not so much by underbidding in price as by embodying the best engineering features.

It would be difficult to overstate the character and importance of the work that Mr. Reynolds accomplished during his unostentatious life. In brief, he was the foremost practical man, the responsible technical manager, in an engine-building establishment which, under his guidance, grew to occupy a position in the very front rank of reputation, and in point of magnitude to surpass all others in the United States. The machinery built by it has been of varied nature; it has included many large Corliss-engine units for pumping service, mining, air compressing, furnace blast, street-railway work and other purposes. In the name of the "Reynolds-Corliss" type of engine, this engineer received one of the deserved marks of recognition which raised him out of anonymity in his business relations with the public.

To him especially is attributed the use of compound and triple-expansion engines in manufacturing plants, one of the first large ones employed for that purpose being installed by him in the Eagle Mills, at Milwaukee, in 1878. He was the first to build the low-speed direct-connected type of engine for driving a generator.

Among achievements of his life, long before the close, was the construction, in 1888, of the first triple-expansion pumping engine built for waterworks service, which he installed at Milwaukee, to run under a pressure limited to 80 pounds. The steam consumption proved as low as 13.84 pounds per indicated horsepower per hour. Some time later, two engines installed in the West Harrison street station, Chicago, showed a steam consumption of 12.67 pounds, which was believed to break the existing economy record. An engine built for Omaha, with 40-, 70- and 104-inch diameter steam cylinders had a capacity of 18,000,000 gallons in 24 hours, raised 310 feet. A 30,000,000-gallon triple-expansion pumping engine was built for the Boston waterworks, its installation being completed in December, 1898. It made the world's record for efficiency and economy of operation, its average consumption of dry steam per indicated horsepower per hour being 10.335 pounds, and its duty per 1000 pounds of dry steam, 178,497,000 foot-pounds. A 15,000,000-gallon triple-expansion pumping engine for the St. Louis works, also built by the Allis company, proved a close second, showing an average dry-steam consumption of 10.676 pounds and duty of 179,454,255 foot-pounds.

When constructing an engine for flushing the Milwaukee river with Lake Michigan water, Mr. Reynolds designed a propeller-type pump, which was built against strong opposition, but the performance of which amply vindicated his judgment. The efficiency of the wheel was 86.75 per cent. The large centrifugal units for sewage plants, each driven by vertical shaft from a horizontal triple-expansion engine, with piston rods 120 degrees apart, originated in his fertile brain. The centrifugals were originally designed to handle Boston sewage.

Another product of his skill is the Reynolds ore stamp, in which he substituted a solid cast-iron foundation for the wooden spring bottom that formerly had been deemed necessary. The result was nearly 50 per cent. increase of output. This invention added much to the value of the great copper properties.

When he built his blowing engine for the steel works at Joliet, Ill., he stirred up the experts. Although his design marked a radical departure from previous types, its valuable features were recognized at once and received the contract. Andrew Carnegie ordered one like it before it had been running a month, this being the beginning of work for the same company that many years ago had amounted to $5,000,000.

Among other works of Mr. Reynolds was the combined horizontal and vertical reversing engine built for the American Steel and Wire Company, at Worcester. The cylinders of this engine were both high-pressure, 44x60 inches, the construction leaving one end of the shaft free for direct connection to the rolls and doing away with the gears, which have always been an objectionable feature.

An instance of the marvelously quick inventive genius of Mr. Reynolds was afforded when he designed the engines for the Manhattan elevated railroad, of New York. A staggering problem of getting a maximum of 12,000 horsepower in limited space and without undue weight on the bearings seems to have been very simply solved, and the weight of the flywheel was reduced one-half. This engine may be taken as illustrative of the building up of the Allis business by Mr. Reynolds. The contract was secured because as an engineering proposition the design submitted was so superior to others offered in competition that the price was a secondary consideration. As a sample of the confidence in Mr. Reynolds' judgment and skill, $3,000,000 worth of this type of engine were ordered in a lump before one of them had been built and erected. Regarding the circumstances attending the design of the Manhattan engines, the following anecdote is related:

The Allis-Chalmers Company, having built eleven 3500-kilowatt standard cross-compound, vertical, direct-connected engines for the Metropolitan Railway Company, was called upon for advice as to the type of engines to be used in the immense new power house then being planned by the Manhattan Railway Company, in New York City. It was the intention of their engineers to install units of 5000 kilowatts capacity. The first type of engine considered was the cross-compound, vertical machine, similar to those furnished for the Metropolitan Railway Company, and some correspondence passed between Mr. Reynolds and the engineers of the Manhattan Railway Company on the subject, so that finally Mr. Reynolds was invited to visit New York and discuss the matter in detail. Mr. Reynolds left Milwaukee with the question of the type of engine still unsettled, but with the understanding that the straight, cross-compound, vertical unit would be used if it were found practicable. Mr. Reynolds was traveling from Albany to New York when the question demanded his attention, and he was informed by telegram that a committee representing the owners of the elevated road would meet him at the Grand Central station. During the ride down along the Hudson he thought the matter over; then, as the train reached the Harlem, he hastily sketched on the back of a letter the substance of the plan ultimately adopted, including the practically unique design of the horizontal-vertical, four-cylinder compound engine, with cylinder sizes and approximate dimensions of all other principal parts, such as crank pins, crosshead pins and main journals. When the work came to be laid out on the board, there was very little variation from his original figures. At this time, Mr. Reynolds, in common with the engineering world at large, expected to see similar engines installed in all important urban stations where realty values were an important consideration; but the steam turbine was then beginning to demonstrate something of its possibilities, and many large projects were held back until the merits of that type of prime mover could be more definitely determined, with the result now universally known.

Mr. Reynolds' ability was not evidenced by his engineering successes exclusively. He was also the man of business. It was by the combination of engineer and business man and all-round manager that the enterprise with which he was associated has so marvelously grown. He was held in the highest esteem by Mr. Allis. In the will of the latter, who died about the beginning of the nineties, he was named as one of the trustees of the Allis estate. Upon the reorganization of the business, which followed, he was elected director and second vice-president of the E. P. Allis Company.

In 1901, the Allis-Chalmers Company, with $50,000,000 capitalization authorized, was formed to consolidate the E. P. Allis Company, Fraser & Chalmers, Gates Iron Works and Dickson Manufacturing Company. In the organization Mr. Reynolds played a prominent part, being a director and the chief engineer of the new corporation. This gave him the opportunity of laying out at West Allis, a suburb of Milwaukee, the great engineering and machinery building works which constitute one of his proudest monuments. It is so constructed that it never can be what was Mr. Reynolds' principal aversion, an "accretion"—the adding on of one building or leanto after another, without proper sequence. Instead, it is built throughout on the unit system; the structures of general utility being capable of indefinite extension toward the rear, with space for the corresponding machine shops to lie at right angles between them.

In the fall of 1905, Mr. Reynolds retired from active service, with the title of consulting engineer, and, although in feeble health, he maintained a happy, helpful existence at his beautiful residence on the hights overlooking Lake Michigan, loved and honored by all his associates.

Mr. Reynolds was interested in various business undertakings outside of the Allis company, being president of the Daisy Roller Mills, Milwaukee Boiler Company, German-American Bank and Morning Mining Company.

The University of Wisconsin conferred upon him the degree of LL.D., and later placed his name upon the frieze of the new engineering building. He has received honors from institutions of learning throughout the civilized world. His election to the presidency of the American Society of Mechanical Engineers for 1901-1902 was a recognition of his eminence in the profession, which the society honored itself by conferring. He was received into active or honorary membership of the leading engineering societies at home and abroad, and he became the first president of the National Metal Trades Association.

The influence of Edwin Reynolds remains expressed not only in mechanical types, but in human personalities. To be a brilliant designing engineer, particularly in the field of power generation and application, is a matter of self-gratulation to anyone so gifted, and is a benefit to many affected by his work; but to lead the way so plainly that others may follow with no uncertain step, to train a large number of young assistants so that they become efficient, original co-workers and themselves the chief officers of engineering works, and to found, develop and leave in sound condition a great manufacturing establishment—such is the province of a master mind, one of the few which a century produces.

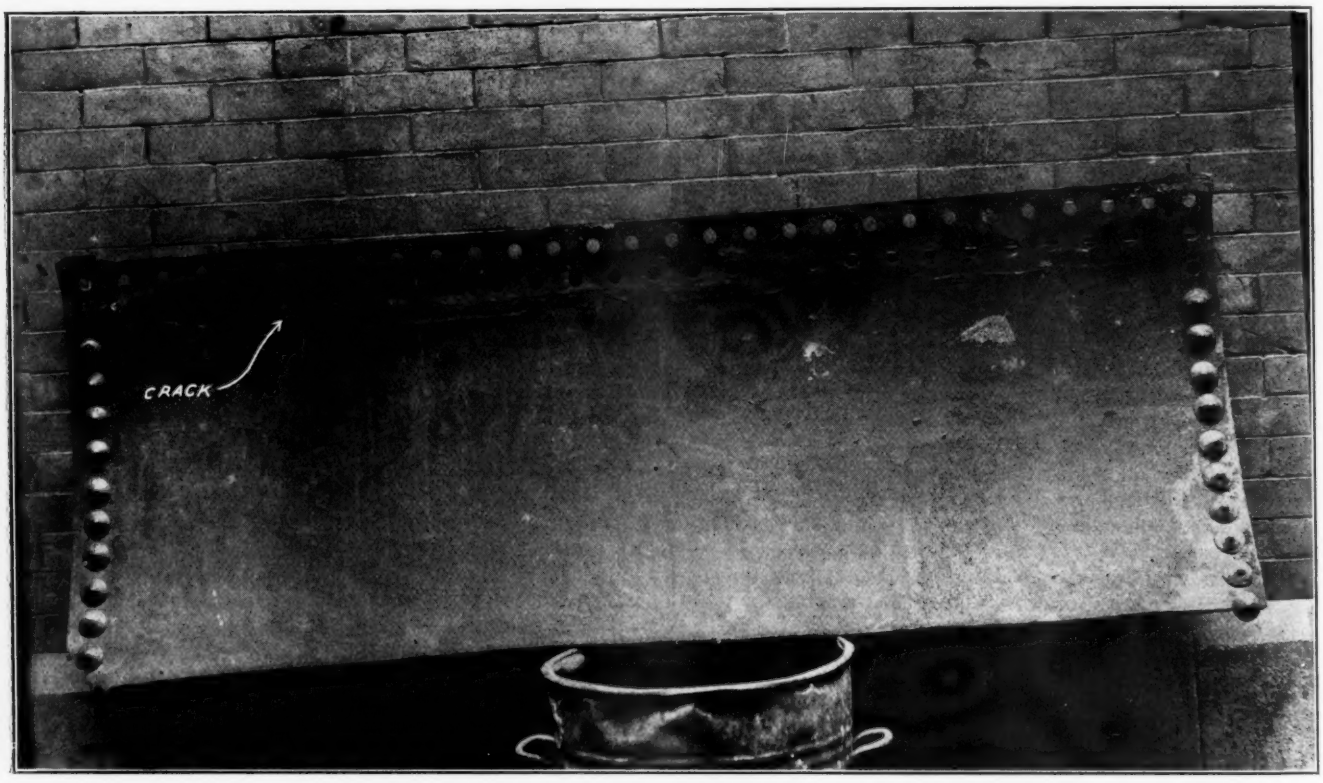
A good paint for boiler fronts can be made from asphaltum let down with turpentine or coal tar mixed with graphite and thinned with turpentine.

That Harwood Boiler

In our issue of December 15, under the title "The Lap Seam Boiler Again," we described the finding of a cracked sheet in a boiler belonging to the Charles E. Harwood Counter Company, of Lynn, Mass. The engineer noticed steam coming through the brickwork, put the boiler out of commission, and inspection showed that the middle sheet had cracked. Our original article said: "Removal of the brickwork over the leak revealed a crack 18 inches long in the outer sheet along the row of rivets," and the article assumed that it was one of the hidden cracks the recurrence of which has caused so many failures of lap-seam horizontal tubular boilers.

In our issue of December 22, Arthur M. Clawson presented a more detailed account of the accident in which he said: "The crack was not located under the lap as has generally been found to be the case, but ran parallel to the edge of the overlapping plate."

We have recently had the opportunity to inspect the plate in question, which is in the office of the chief boiler inspector at the State House in Boston, and have obtained the photograph reproduced herewith. The crack is shown in the upper left-hand portion of the sheet just under the lower row of rivets and is very plainly one of the hidden internal cracks occurring, as is usually the case, just under the edge of the rivet heads and so hidden by the inside sheet as to be impossible of detection by any inspection short of unmaking the joint.



SHOWING CRACK IN SHEET OF THE HARWOOD BOILER

Saving Life and Property

The American Anti-Accident Association held open meetings Thursday afternoon and evening, February 11, in the Y. M. C. A. hall, 215 West Twenty-third street, New York City, for the purpose of presenting and receiving ideas as to the true underlying causes of accidents, the best way to prevent them, and incidentally to augment the number of its members.

It is the intention of the organization to establish boards in our towns and cities that would be under the control of the State, with a national head, and similar in a great many ways to our present boards of health. Its purpose is the education of carefulness in homes, schools and vocations, to develop a greater realization of the suffering and afflictions caused by accidents, and to create a public sentiment which in time will cause anything pertaining to the prevention of accidents to command the highest humanitarian consideration. Thomas D. West, president, discussed the fundamental features involving work for the association, and other speakers, such as Edward Bunnell Phelps, editor of *The American Underwriter*; W. H. Tolman, director of the American Museum of Safety, and L. P. Alford, of the *American Machinist*, took up the subject of accidents and their prevention in its different phases.

Some Useful Lessons of Limewater

Interesting Experiments in Softening Temporary- and Permanent-Hardness Waters; the Importance of Chemistry; Its Chief Elements

BY CHARLES S. PALMER

There is one suggestion that may well be made at this point; that is, that you will save time and effort in getting things cleared up and in remembering things if you just *talk* these lessons over with some friend who is interested with you. The reason for the gain is that you will talk *your* notions out, and you will hear the notions of your friend; you will find your eye, ear and hand working together to help your mind in grasping the facts, in remembering them and, most important of all, in using them. But to get back to the hard water:

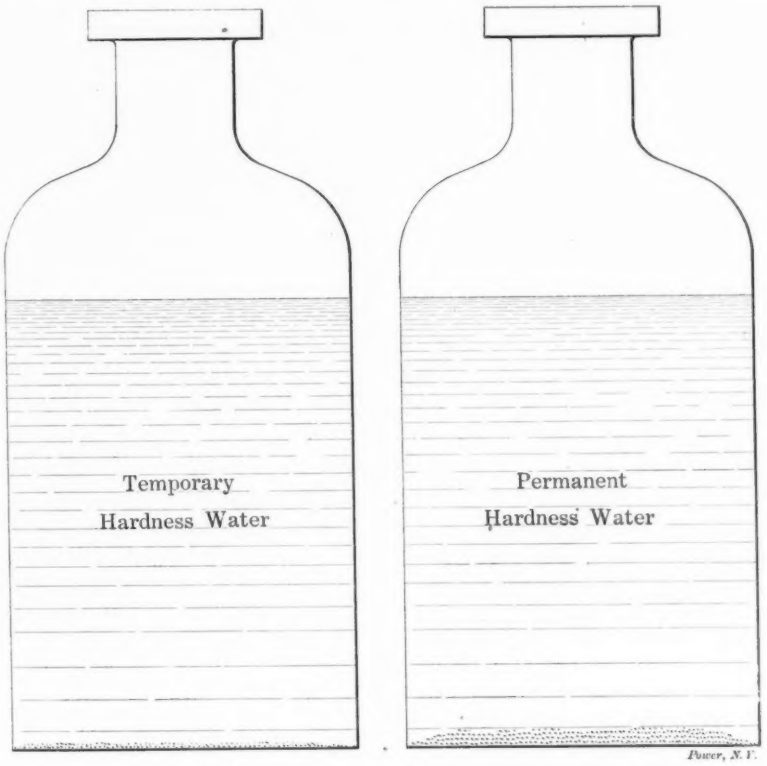


FIG. 1

Softening Hard Water

Get two large bottles of clear glass. Common quart bottles will do, but if they are large enough to hold several quarts, so much the better. Pour into one of these, until three-quarters full, a solution of temporary-hardness or carbonate-hardness water, throwing in with it two slips of litmus paper, one red and one blue. Pour into the other bottle, until three-quarters full, a solution of permanent-hardness or sulphate-hardness water, also putting in two similar slips of litmus paper. You may not get many surprising results from the litmus paper, but you will have the satisfaction of knowing that you have kept your eyes open in that direction; and litmus paper will always tell you something. If the solution of carbonate-hardness water is strong with carbonic acid, you may almost get the litmus paper red; but you should remember that litmus paper turned red by carbonic acid will turn blue of itself usually, if taken out of the solution, as it dries in the air; because carbonic acid is volatile and is driven off by the nonvolatile red acid in the litmus itself. We will return to this subject of litmus paper a little later, for it teaches one much about the acid and the basic parts of "salts."

Now throw into the bottle of temporary-hardness water or carbonate-hardness water about a teaspoonful of milk of lime, shaking the bottle well, and letting it stand. You want to learn how to add just enough of the milk of lime to soften the water by Clark's process, and there are different ways by which you can tell this. One way is to let the water settle clear, pour out a few drops and add some filtered limewater; if there is still any extra or bicarbonate of calcium in solution, there will be a slight milkiness; and you keep on adding the milk of lime until there is no more milkiness on adding filtered limewater to the clear hard water. Another way to tell whether you have added enough milk of lime to the temporary-hardness water is to note the litmus paper; as soon as you have added just a bit too much of the milk of lime, the water will change the litmus to blue, because the milk of lime is itself a turbid solution of limewater. To the bottle of permanent-hardness or sulphate-hardness water you will add a solution of soda ash (or sodium carbonate or washing soda, they are all essentially the same thing). You will also know in this case, as in the other, when you have added enough soda ash. Let the water settle clear, and then test a few teaspoonfuls, poured out into a tumbler, with some of the soda solution to see whether there is more precipitation. Keep this up until you get no farther precipitate; also watch the litmus paper, it may tell you something.

Now let both bottles of hard water settle, noting the time required to get clear solutions. It may take some hours, sometimes nearly a day or even longer. All this will cause you to do some thinking. It will suggest that large settling tanks may be necessary. It may suggest that it will pay you to look up some of the newer ways of clearing hard water. There are some processes which, with some waters and in some localities, do give really good results; but all this will help the selling agent give you a scientific explanation for what he tries to do, and which he may really be able to do. You will note that the *quantity* of softener is one thing; that you have begun to study. You also note the *time* taken for the water to settle, but it will be well for you to try the settling warm and cold; these things sometimes make all the difference in the world.

But there is another thing that you want to note; that is the way to *mix* the softener with the hard water. It is one thing for you to add a teaspoonful to a bottle which you can shake up with your hands, and it is quite another matter to mix a pailful of the softener with a 500- or 1000-gallon tank of water. It is worth while for you to study how this mixing is to be done. Will you feed the softener into the water supply in a constant small

stream? Or will you throw in a bucket or barrel of it at a time? The special form of apparatus must attend to all these matters and must do it right.

Then there are some of the other things which get into "hard" water; for, as we have noted already, it is not alone lime and its compounds that make water hard, but often the compounds of magnesium, and perhaps one or two other metals. Also, while much temporary-hardness water has to do with carbonates and much permanent-hardness water has to do with sulphates, yet there are some other complications, such as the *chlorides* of magnesium, which are not only difficult to throw out of the water but which also corrode the boiler iron. As you examine the samples of scale which you will collect you will find some iron in all of them, and this iron stain is or may be partly from the water, and partly from the iron tubes or plates themselves; so you see that all scale is not only in the way, but it is also a corrosive, eating thing. All this suggests that there is much to be learned about the scale-forming substances, and this means that we must use this study of lime as a broad basis for getting hold of enough chemistry to understand the action of both scale formation and burning. And, in the study of burning or combustion, or "oxidation" in its broadest way, we shall have to dip into *wet* chemistry, and *dry* chemistry, for there is a dry combustion and there is a wet or moist combustion. All of this, or some of it, will come along in due time.

But just now turn your eye to the experiment shown in Fig. 1 and note the amount of sediment which has formed or gathered in each bottle. You will see that in both bottles there is the *same* insoluble sediment, plain carbonate; and you must stop and think how it is that you get the lime-like part of the hardness thrown out of solution from either temporary- or permanent-hardness water, as this same old plain carbonate. You will remember that this plain carbonate of lime came from the extra carbonate, by heating or by addition of limewater or milk of lime; and you will see that you get this same plain carbonate from sulphate water and soda ash. But in the case of the temporary-hardness water you left the water nearly pure, while in the case of the permanent-hardness water you had to leave the water as a dilute solution of sodium sulphate.

Testing the Sedimentation

It will be a good thing if you collect the sediments from both the bottles shown in Fig. 1 and test them. First, just note the relative quantity. You will usually find that there is more sediment from sulphate-hardness water than from temporary-hardness water, although both are the same chemical compound, plain lime or calcium carbonate. Again, you will want to test both of the sediments with hydrochloric and nitric acids, when they will entirely dissolve with effervescence; that is, bubbling of some gas which you will rightly guess is carbonic-acid gas. Now if you test the clear solution left in the bottle that had the temporary-hardness water you will find that it is nearly pure water, with a little lime from the slight excess of milk of lime; but when you test the bottle of purified permanent-hardness water you will find that it has considerable sulphate of soda (Glauber's salt) in it. The sulphuric part you can test for by the same way used in the test given near the last part of the third lesson in the February 16 number.

You pour a few teaspoonfuls of the water left in the permanent-hardness water of Fig. 1 into a tumbler or test tube, and then add a few drops of your solution of barium nitrate. Down comes a quick cloudiness, which soon settles as a heavy sediment. Now try this with either hydrochloric or nitric acid, or both; its persistent insolubility shows that it is barium sulphate, the common test for sulphuric acid or the sulphates. But there is still the sodium part of the

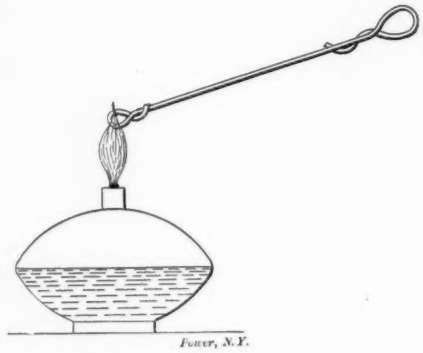


FIG. 2

Glauber's salt, left from the softening of the permanent-hardness water, to test for. It is not easy to throw the sodium out of solution; but if you take a clean bit of iron wire and moisten it with some of the solution of sodium sulphate left from the bottle of permanent-hardness water and then hold it in the flame of an alcohol lamp (Fig. 2), or of a common gasolene or gas stove, you cannot help noticing the strong *yellow* flame produced, and that is due to the sodium. You can always get this yellow flame from any of the sodium compounds, but you cannot easily throw sodium down from solution. Indeed, it is one strange peculiarity of sodium that of all of its hundreds of salts about all of them are soluble in water, and you will find when you get on farther into analyzing things that there is no good, easy way of throwing sodium completely out of solution in the insoluble form, as you can easily do with lime in a score of ways.

Chemical "Elements"

You will have a good deal to do with analysis as you go on with these lessons, and with other studies in chemistry later; for live as long as you will you will never get beyond the study of chemistry, which is the separating of things into their ingredients, putting back those ingredients so that you can get the original substance, the letting of this substance act on that and the reaction of that on this. From the air and water to the earth everything is made up of chemicals, and the curious ways in which things act on each other make up the study of chemistry. As you begin to separate things into their ingredients you get simpler things, and these can be separated into still simpler things, and so on. But before long, you come to a set of things that can't be separated into anything simpler, and those things are called "elements."

There are between seventy-five and a hundred of these elements, but only about twenty or twenty-five are of common importance; and you will have to do with only about a dozen at the start. You have had something to do with the element carbon, which makes up the bulk of coal, and which also is in carbonic-acid gas. You know sulphur, or brimstone, which is the thing at the bottom of sulphuric acid or oil of vitriol—sulphur is another element. The air is mostly made up of two gaseous elements: Nitrogen, which for the most part in the air is only a "filler," as far as burning goes, and oxygen, the element that helps burning. The common metals, iron, lead, zinc, copper and tin, the less common mercury, silver and gold, the new metal, aluminum, these are all elements; they cannot be separated into anything but themselves; at least, not up to date, for in these piping times of new and strange discovery it is not well to say that anything is impossible to the thousands of chemists who are hard at work after the secrets of nature. But if the elements are made up of anything simpler they have forgot to say anything about it, except possibly in the curious cases of uranium and radium; all of which has apparently little to do directly with hard water, but a great deal indirectly, because you want to learn analysis, so you can find out for yourself what are the ingredients, and what are their relative quantities, in the substances you handle every day.

You perhaps have never seen or handled the metal sodium, also an element; but you may like to be reminded that it is probably the stuff which the street fakir on the corner uses to light his pipe when he seems to light it with a bit of ice. He packs his pipe with common dry tobacco and tucks down on top of this a piece of the metal sodium (or perhaps of potassium, which is much like sodium, only stronger); then he touches the "quick" metal with ice, which is only so much solid water, and the heat resulting easily makes fire enough to light the tobacco. Theory says that when metals like sodium and calcium unite with oxygen they

should first form the oxides; and calcium does form its oxide, CaO, quicklime; but sodium's oxide is so thirsty for water that it does not stop at the oxide, as calcium does, but at once goes right on to the water compound, NaOH, sodium hydroxide or hydrate, or caustic soda. That the lime metal, calcium, does form both the plain oxide (quicklime, CaO) and the slacked lime, $Ca(OH)_2$, is interesting (as shown in the February 23 number). It is also interesting to know that there is a flame test for this lime metal, calcium, just as there is a flame test for the salt metal, sodium. Take a little of the milk of lime and add just enough hydrochloric acid to it to dissolve it all and leave it barely acid, or nearly neutral. Of course, you now have a solution of calcium chloride. Now make a loop of clean iron wire, as shown in Fig. 2, dip it in the lime solution, and hold it in any colorless flame, as the flame of an alcohol lamp (you can make an alcohol lamp out of an ink bottle), or of a gas stove, and note the bright orange-red flame. That is the calcium flame. There is a special and a beautiful scheme of studying flames (with an instrument called a spectroscope); the science is called spectrum analysis; but these tests of sodium and of calcium are two of the fundamental tests. You can carry this testing of metals on quite a way by yourself, if you file any metal, iron, copper, zinc, lead, tin or silver. Gathering a pinch or two of the metal dust on a sheet of paper, sprinkle them, one at a time, in any hot and fairly colorless flame. You will be surprised to see what elegant and beautiful "parlor fireworks" one can get by simply burning the filings of any common metal in a hot flame; the dust will burn like powder, and with a different-colored light in each case.

This all goes to show how great is the subject of chemistry; but it will help us if we stop and ask ourselves: What are the really great and important subjects in chemistry? We will not let ourselves get confused by any absurdly complicated answers, but we will stick to a few fundamentals. The great subjects in chemistry are: First, *fire* and *water*; second, *acids* and *alkalies*; and of the acids, sulphuric acid is easily king, as the soda compounds make the queen set of alkalies. But in much of all of this you will find our good friend lime plays an important part. The story of lime has only been begun.

On page 64 of the January 5 number, in John B. Sperry's letter on "Pump Suction Limit," the second half of formula

$$A_p = \textit{Total suction limit} =$$

$$H = \frac{v^2}{2g} + F_p,$$

is erroneous. It should have been

$$H + \frac{v^2}{2g} + F_p.$$

Central Station versus Isolated Plant

As bearing upon the vexed question of the extinction of the isolated plant by the central station, we reproduce the following open letter, addressed to the Public Service Commission of the State of New York by Percival R. Moses:

"Gentlemen: The question of rate discrimination, as between the large and small consumer is presented for your consideration. So far the result of your rulings and investigations on this subject has been twofold:

1. To make the methods of discrimination matters of public record.
2. To make the discrimination practiced between various classes of consumers equal, *as between classes.*

"Do you mean to stop here and leave the main question unsettled?

"On behalf of the great majority of users of electricity, and of all whose interests are connected with isolated plants this plea for a 'square deal' is presented. Let the selling price of electricity be based upon the cost of manufacture and distribution plus even a liberal profit and let the present system be stopped of charging on the basis of 'all the traffic will bear.'

"Under present methods the user of a small quantity of electricity is charged three or even four times the rate charged the user of a large quantity, because the small user has no competition to offer, while the large user has, in the shape of the isolated plant.

"Occupants of lofts in large buildings where isolated plants are a possibility, by combining with the owners pay from 5 cents down per kilowatt-hour, while occupants of lofts in small buildings where isolated plants are not economically possible have to pay 10 cents per kilowatt for light and from 10 cents to 6 cents for power. Owners of small stores are charged 10 cents per kilowatt-hour, while owners of large stores pay as low as 3 cents. Apartment-house residents pay 10 cents if the building does not use 120,000 kilowatts per year, but if it does use this quantity the electricity they use is paid for at 5 cents per kilowatt-hour. In all the foregoing instances the cost of manufacturing and supplying electricity to the small users is substantially the same as the cost of manufacturing and supplying electricity to the large user. Where, then, is the justification for a 300 per cent. discrimination?

"A certain difference in rates between current used during a short period per day and current used for a long period per day is justifiable because of greater fixed charges per kilowatt-hour supplied, but there can be no justification for any discrimination based on the total quantity of electricity used.

"The Edison and its allied companies operate under a monopoly granted by the whole body of citizens, and it is established law that all citizens shall be treated equally. Where is, then, the justification for the unequal rates to small and large consumers?

"Mr. Jones, occupying a store 10x12, with 10 lights, costs the company but little more—not 10 per cent.—to supply per kilowatt of use than Mr. Smith with 2000 lights. Yet Mr. Jones will pay 10 cents and Mr. Smith less than 5 cents per kilowatt-hour. When Mr. Jones goes home to his small apartment he will again pay 10 cents per kilowatt-hour, but Mr. Smith, if he lives in a big enough building, will pay, or his landlord will pay, only 5 cents per kilowatt-hour. The cost to the Edison company is exactly equal in each case. Is this condition to be continued? If so, why?

"If the Edison company can manufacture and sell current for lighting to the large store, apartment house, or hotel or other building for from 2½ to 5 cents per kilowatt-hour, the rates to small consumers are far too high and they should be reduced to the rates charged the large consumers for the *same kind* of service irrespective of the total amount of their use."

Burning Ash

The contention that coal should be burned as completely as possible when it is first on the grates, and that the practice of refiring any of it is more often a source of greater loss than it is of economy is well borne out by the following results of recent tests conducted by the Arthur D. Little laboratory, of Boston.

Just previous to these tests some of the grate bars had burned out very rapidly and allowed a considerable amount of coke and siftings of coal to be taken out in the ash conveyer.

The better part of the ash pile was returned to the coal conveyer and delivered to the overhead bins, where it was mixed with the coal and was being reburned at this time. At first thought it was considered to be the proper thing to do, but a sample of the coal and ashes being fed to the boiler indicated that there was a considerable increase in the percentage of ash in the fuel being fed and that the loss due to unburned coke invariably increased with this, so that instead of feeding to the stokers New River coal which contains about 6 per cent. ash this material contained 11.74 per cent. ash.

The ashes and refuse being taken from the pits contained nearly 40 per cent. of combustible, corresponding to a loss of 8.3 per cent.

From these analyses and the analysis of refuse being put into the coal bunker, the chemical engineers calculated the amount of ashes being refired to be about 16 per cent. of the coal.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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Edwin Reynolds

The death of Edwin Reynolds, announced in another column, has not come unexpectedly. For several years after he had passed the allotted span he continued in active charge of the great Milwaukee works in the creation of which he was so large a factor. But, three or four years ago he began to fail, and his friends have long known that the end was imminent.

The story of his life, as told elsewhere in this paper, is that of another rugged genius who, without exceptional advantages of birth or education, threw himself into his work as he found it, did it not merely for so much per hour but because his interest was there—because he loved to do a good job and to see it *go*—and he naturally became a power in a field where there was a great development and developed with it. It was largely he who molded the slower-speed and larger-sized engine into the forms demanded of it through the successive changes of the development of large central-station work, and who stood ready to adapt the materials of nature to the varying demands of man. The great works which he planned for this purpose, as well as the many notable products of this and other works with which he has been connected, will be living monuments to his genius and industry.

Foundation Vibration

Vibration from generating units causes more or less annoyance in office buildings, and is due to the condition of the soil upon which the foundation is built, the unbalanced condition of the engine and, possibly, unequal distribution of load in the cylinder.

Many unique methods of preventing vibration transmission have been devised with more or less success. In one instance the ingenious engineer carried out the scheme of building a scow upon which were placed a small engine and generator that had given trouble from vibration. The scow was placed in a tank of water, and although the idea cost money it prevented all vibration from being transmitted to the building.

In another instance the engine was to be placed in the basement of a building built on a ledge. In order to overcome the transmission of vibration from the engine a portion of the ledge where the engine was to be set was cut away and a layer of asbestos felt placed under and around the engine foundation, which was then built in the usual manner.

These methods of preventing transmission of vibration have been confined to reciprocating engines, but from recent advices it seems that it has been deemed advisable to take precaution against this trouble in steam-turbine operation. At St. Pancras, England, the borough council has recently put in operation a 2000-kilowatt steam turbine mounted on a special rubber foundation as a precaution against vibration, such as has given trouble from reciprocating engines.

An ordinary concrete foundation has been built, upon which rests the turbine with its rubber foundation. The turbine is bolted to a slab of concrete about two feet thick, which is reinforced by steel bars, and between this concrete slab and the foundation proper are placed a number of 4x3-inch circular rubber pieces. No part of the turbine or concrete slab above the rubber pieces is allowed to come in contact with the floor, thus preventing any possibility of vibration being transmitted to the building.

From what is known of steam-turbine operation this precaution would seem unnecessary if the machine is in proper balance, and there is no reason why it should be put into operation until it is. In justice to the contractors of this installation it can be said that they were willing to guarantee that the turbine would run without vibration.

Cultivate the Habit of Observation

To see without noticing is one of the commonest habits of mankind, and this fact has been taken advantage of by a class of men who call themselves "Business Doctors." They have cultivated and improved the faculty of noticing what they see. They go into business houses and industrial establishments and, without previous experience in any particular line, except that of observation, put their fingers on sources of loss. Under their direction, methods of business are reorganized and industrial establishments are remodeled. Wastes are stopped, losses reduced and production increased. Members of this same class of men have turned their attention toward the power house, and lubricating engineers, combustion engineers, supervising engineers and what not are looking for revenue from the mistakes of carelessness and ignorance on the part of the operating engineer.

Claiming to have saved in some instances as much as ten per cent. of the total fuel used in large industries, by intelligent use of the right kind of lubricating and cylinder oils, the lubricating engineer is able to interest the man who pays the coal bills and he often makes good, because the engineer has not noted the things which he has seen while attending to matters of lubrication. Altogether too often with the engineer oil is oil, and as long as bearings do not unduly heat one oil is just like any other oil. Observation is the long suit of the lubrication expert and he notices every spot where oil is

used and how it is applied, and he gets from an apparently simple glance at things in general an amount of information that the engineer would not acquire in a lifetime, because he naturally notices only that which is out of the ordinary, while the habit of observation cultivated by the expert teaches him to see all that is not ordinary in ordinary things.

Sometimes the engineer uses new oil on a part of his plant and filtered oil on the rest of it. Sometimes all of the new oil used in a plant is added to the oil already in the filter as makeup oil and only oil from the filter is used for lubrication. But how often does the engineer know or even think whether the machinery under his care runs with less friction in one case than in the other? In an installation of five hundred or more horsepower, a saving in the amount of friction of even one per cent. is an item which is well worth looking after, and the ignorance of the man who directs the oiling of this plant is the opportunity of the lubricating engineer.

In the boiler room it is the same. Improper and unintelligent methods of firing may obtain, cold air may seep through the known or unknown cracks and openings in the boiler setting, lowering the furnace temperature and the temperature of the products of combustion before they reach the heating surfaces of the boiler, reducing the efficiency of the plant.

Through various channels, the outsider is invading the field that belongs especially to the engineer and with more or less success as the engineer is alert or inert. Obviously, the moral pointed to is that the man who is in the power plant and responsible for its operation should know more about every detail of its operation than any outsider, however well trained he may be. Special knowledge comes only as the result of special application and the engineer has better facilities for special study of his own plant than any other man in the world and should take advantage of them.

State Supervision of Boilers

Even those who most loudly decry paternalism on the part of the State, and governmental interference with the prerogatives of the individual, will not deny the right of the State to insist that steam boilers shall be used under such conditions as not to menace the public safety.

The Massachusetts law contains a provision for a Board of Boiler Rules, consisting of the chief of the boiler-inspection department, one representative each of the boiler-using, boiler-manufacturing and boiler-insurance interests and an operating engineer. This board is directed "to formulate rules for the construction, installation and inspection of steam boilers, and for ascertaining the safe working pressures to be carried on said boilers; to prescribe tests, if they deem it necessary, to ascertain the qualities of materials used in the construction of boilers; to formulate rules regulating the construction and sizes of safety valves for boilers of different sizes and pressures; the construction, use and location of fusible safety plugs, appliances for indicating the pressure of steam and the level of water in the boiler, and such other appliances as the board may deem necessary to safety in operating steam boilers."

These rules, when approved by the governor, have the force of law and several sets have been promulgated and reproduced in part in our columns.

It is now contended by some of the boiler manufacturers that certain of these rules transcend the authority of the board in that they are not essential to safety, and efforts are being made to have them repealed. Those to which objection is specially urged are:

Rule 11, sections *d* and *e*, specifying that fusible plugs shall be placed in a tube not less than one-third the length of the tube above the lower sheet.

Section 4. "This board does not recommend the use of externally fired boilers over eighty-four inches in diameter."

The specifying of standard sizes of manhole and handhole and prescribing their location.

The requiring of horizontal return-tubular boilers over seventy-eight inches in diameter to be supported from steel lugs by the outside-suspended type of setting.

The requiring of the feed pipe between the check valve and boiler to be of brass.

Another proposed amendment is for the purpose of exempting the boilers of steam fire engines from inspection, and another the exemption of attendants upon boilers and engines used for horticultural purposes from examination and license.

The board requires builders of boilers built in or coming into the State to fill out a report giving sizes and full particulars, including destination, to the end that the department may have a record of every boiler from its setting up to its cutting up. Another proposed amendment is to the effect that the data so required shall be simple in form, including only information necessary to be known for public safety, and that the manufacturer or person making such report shall not be required to furnish the name of the purchaser or the location of such boiler.

Another proposed amendment provides that the governor shall give notice and hearings before approving rules, and that anybody, making or using boilers, who shall feel aggrieved or injured by any of the rules may petition the superior court for the revocation of the rule.

Still another amendment in one fell, confusing swoop decrees that the board shall make such rules only as are necessary for public safety and revokes all rules heretofore issued not so necessary, without saying who shall decide.

We have had a recent opportunity of examining the system of standardization, inspection and record inaugurated by the Massachusetts department. It is possible that in some respects it does transcend the bourns prescribed by a simple provision for the public safety. A boiler may be perfectly safe with a manhole varying an inch from that which the board has adopted as standard and the use of which is prescribed by the rules; and if the case were taken to court it might be found that even the legislature cannot compel a man to use an 11x15 or 12x16 manhole if he wants to use some other size. At the same time a wide variation from these sizes is not practicable in one direction, on account of inadequacy for a man of ordinary size, and in the other for safe and practicable reinforcement of an abnormally large opening in the shell. The rules allow a variation of half an inch in the foregoing dimensions giving a range of from 10½x14½ to 12½x16½, which ought to cover any exigencies of practice; and the advantage of standard sizes does not have to be explained to those who have had to hunt the town for a gasket, or to replace a broken yoke.

Much is being made of the stipulation that brass feed pipe shall be used between the boiler and the check valve, but in view of the proneness of iron pipe to corrosion and scaling up, and of the possible serious consequences of a breaking out or obstruction of this pipe inside of any valve or possible means of shut off or access, is not brass pipe better and safer? It requires only a nipple between the check valve and the boiler to comply with the rule, and the tendency which would be induced to put the check valve nearer the boiler is also in the direction of safety.

The right of the board to require information of new installations is indisputable and if they are reported the department learns in that way of the destination and location of all new boilers whether made in Massachusetts or imported. Why, then, should the manufacturer object to reporting the destination or purchaser of a boiler as well as its dimensions and proportions?

It would be well enough to provide for hearings by the governor before he approves rules, but protests should be first made to the board, and if the protestants were not able to convince the board of the injustice and inadvisability of a rule it is unlikely that they could induce the governor to withhold his approval. The provision for court review is unobjectionable, but is it necessary? Have not the user and manufacturer all the recourse necessary in the ordinary processes of law?

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

International Harvester Gas Engine

The engravings presented herewith illustrate the details of the latest two-cylinder vertical gas engine manufactured by the International Harvester Company of America, Chicago. As apparent from Fig. 1, the design conforms in many respects to standard construction for vertical single-acting four-stroke-cycle engines, having an inclosed crank case and splash lubrication, valves in the cylinder heads operated by push rods and rockers, and a flyball governor controlling the admission of mixture to the intake manifold. In working out the details, however, absolute interchangeability of parts has been the guiding principle, and there are no "rights and lefts" in its construction. Any piece used for any given purpose on one cylinder may be used equally well on the other, and the positions of the cylinders themselves may be transposed at will.

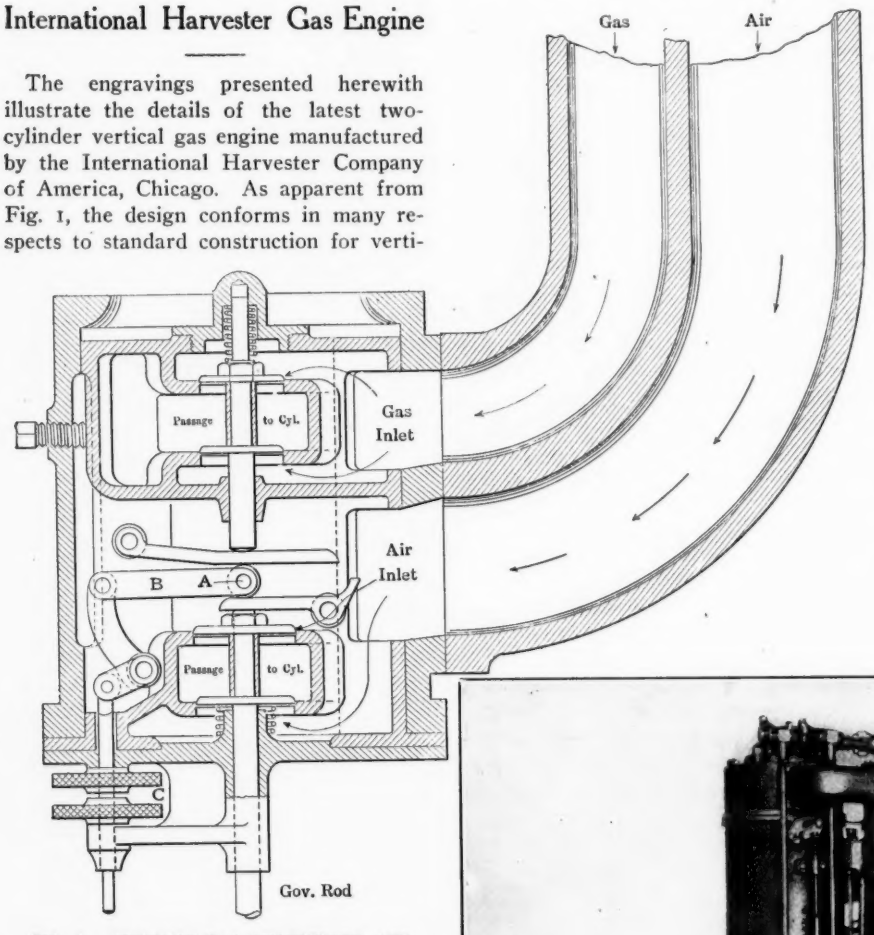


FIG. 2. PRODUCER-GAS THROTTLING AND VALVE MIXER

As shown in Fig. 5, both the inlet and the exhaust valves are in the cylinder heads, and both are mechanically operated from a half-time cam shaft located in the crank case. One size of valve cage is used for both inlet and exhaust valves, and the cages are held in place by two large studs instead of several small ones. To reduce the velocity of the entering and outgoing gases in the valve ports, the valves are made as large in diameter as consistent with the size of the cylinder. The inlet valves are integral with their stems, but the exhaust-valve heads are screwed on their stems to permit renewal of a disk alone if it should become necessary.

Regulation is effected by throttling the mixture of gas and air according to the load requirements. The governor is gear-driven from the cam shaft and is equipped with a spring mechanism designed to take up the shock and jar caused by the cam action. The vertical governor spindle, which extends up through the crank case, as shown in Fig. 5, carries three lugs, which correspond to three similar ones on the governor yoke. Between these two sets of lugs are interposed coil springs, so that the governor-valve stem is not affected by momentary changes of speed due to shock or jar, backlash of the gears, or other similar causes.

Fig. 2 shows in section the combined

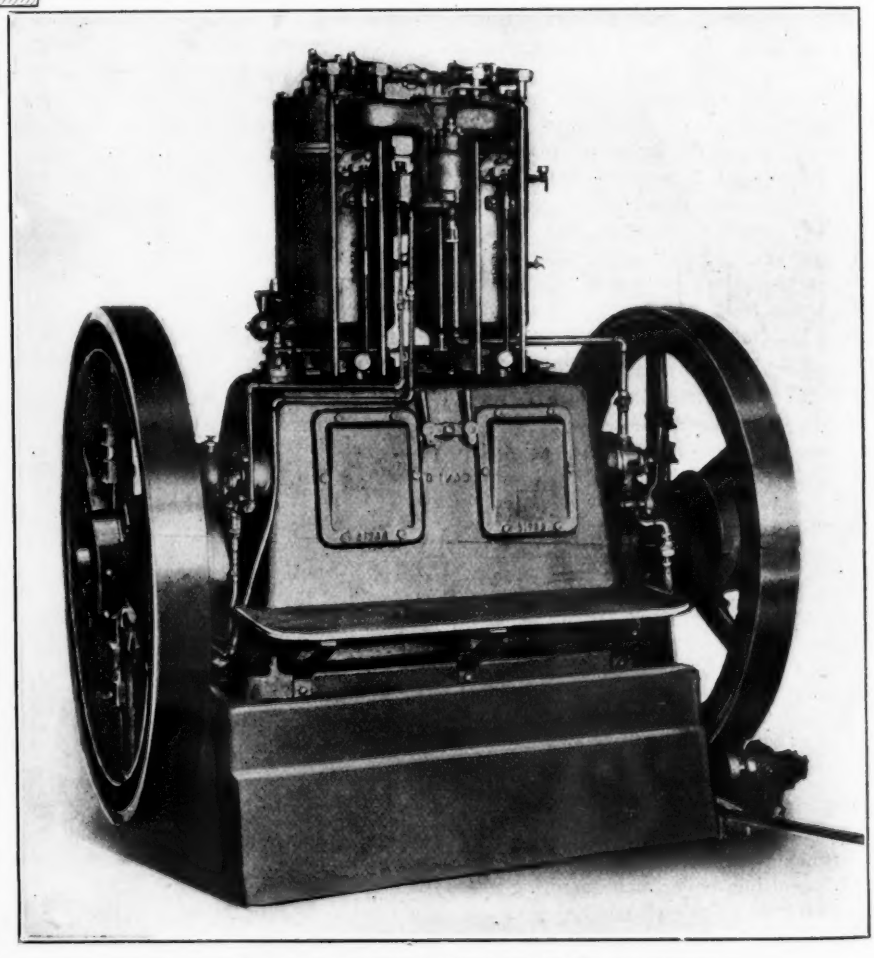


FIG. 1. INTERNATIONAL HARVESTER COMPANY'S GAS ENGINE

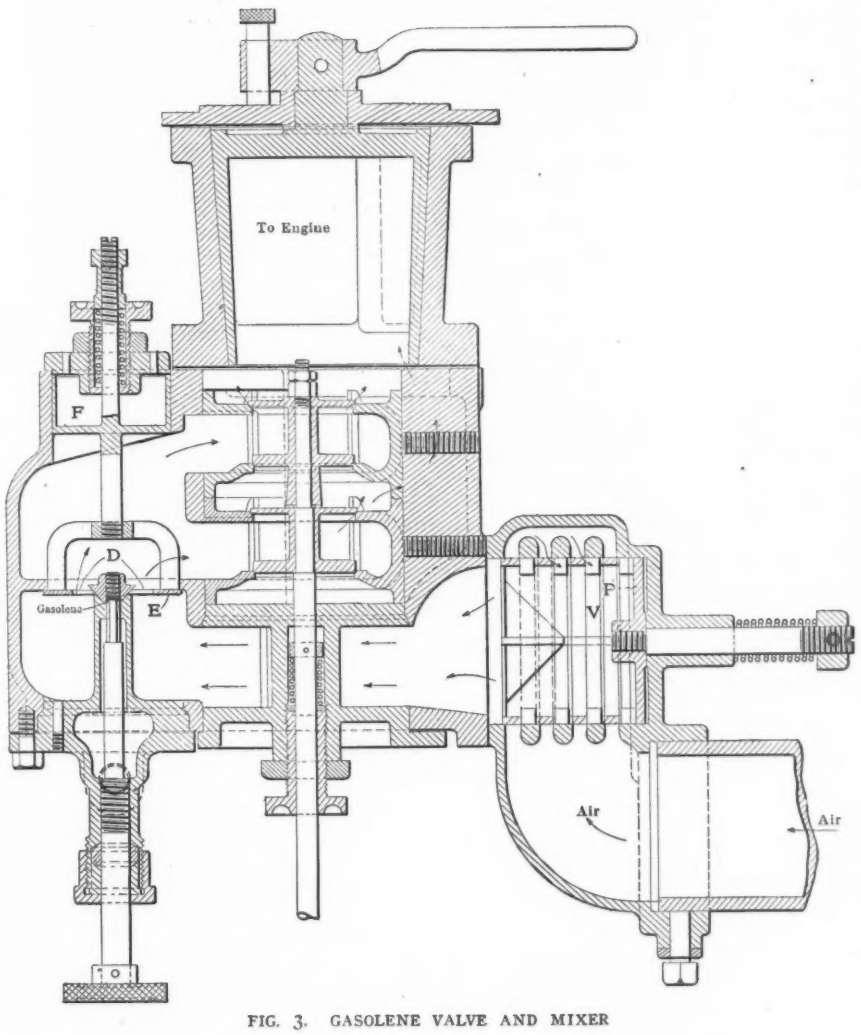


FIG. 3. GASOLENE VALVE AND MIXER

throttling and mixing valve for the producer-gas engine. Both the air and the gas valves are of the balanced poppet type and are raised or lowered by the governor reach rod. It will be noticed that between the gas and air valves is interposed a roller *A*, mounted on the end of an arm *B*, the position of which is adjustable horizontally through a set of links by the adjusting nuts *C*. When the roller is in the position shown, both valves will have equal lift, but when it is shifted over to the right the lift of the gas valve is less than that of the air valve, and *vice versa*. By means of this mechanism any desired quality of mixture may be obtained, within reasonable limits.

The engine is also built to run on gasolene, in which case shorter pistons are provided and lower compression is used. The gasolene-mixing attachment is shown in Fig. 3. The liquid fuel is introduced into the mixing chamber through a cone-shaped nozzle which reduces it to a fine spray. Air is admitted in direct proportion to the opening of the balanced throttle valve *V*, the movement of which is due to the air piston *P* responding to the engine suction. The spring on the horizontal stem pulls the valve back to the closed position after each suction stroke. At light loads, and on starting, all the air passes through the opening *D*, in an auxiliary air valve *E*, the stem of which is attached to the dashpot *F*. All the air then comes in contact with the gasolene vapor and produces a rich mixture, insuring regular explosions. On heavier loads, however, the increased suction pulls down the dashpot *F*, and opens up an annular passage around the outer edge of the auxiliary air valve, allowing additional air to pass through as indicated by the dotted arrows. This arrangement is provided so that with the increased amount of gasolene aspirated at heavy loads, the mixture will not become too rich to fire easily.

Like the valve cages, the igniter plugs are held in place with only two large studs each, making them easy to remove. Make-and-break ignition is used and the movable electrode is provided with an outside bearing to support the end of the spindle and reduce the liability to leakage. Near the top of the crank case, in Fig. 1, will be seen attached to the igniter rods two nurled nuts. By turning these, late ignition for starting may be obtained, and when the engine is up to speed they are turned back for early ignition. Further adjustment of the ignition timing is made by means of right- and left-hand threads on the igniter trip rods.

Starting is accomplished with compressed air by throwing out the valve gear of one cylinder in the usual manner and running on compressed air for a few revolutions. The feature of the starting mechanism is the air valve through which the air is admitted and exhausted from the cylinder. This, as shown in Fig. 4, consists essentially of a tapered rotary valve or plug cock *H*, which is fixed on the end of the cam shaft *J* and rotates with it. The rotating part of the valve is movable endwise on the shaft and, when the engine is in operation, it is held away from its seat by the stem *K* and a small helical spring, so that no wear takes place. When it is desired to use the

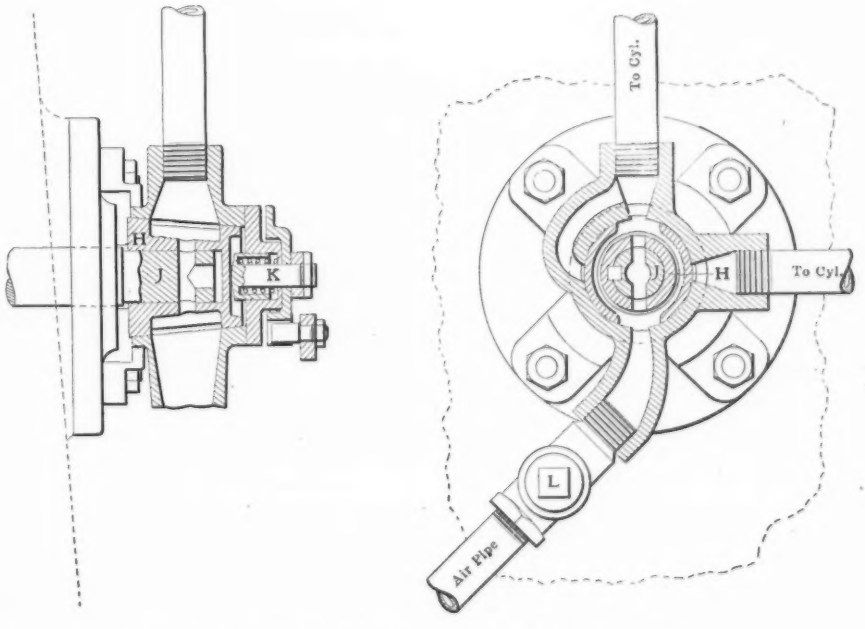


FIG. 4. SECTIONAL VIEWS OF AIR VALVE FOR STARTING

valve, the air is turned on by means of an ordinary plug cock *L* in the supply pipe, the lever of which is connected by an arm with a collar on a beveled seat connecting with the pin *K*. The action of turning on the air withdraws the pin *K*, allowing the air pressure to seat the valve tightly, and it then operates as an admission and exhaust valve until the air supply is shut off, which allows the pin to force the valve from its seat again.

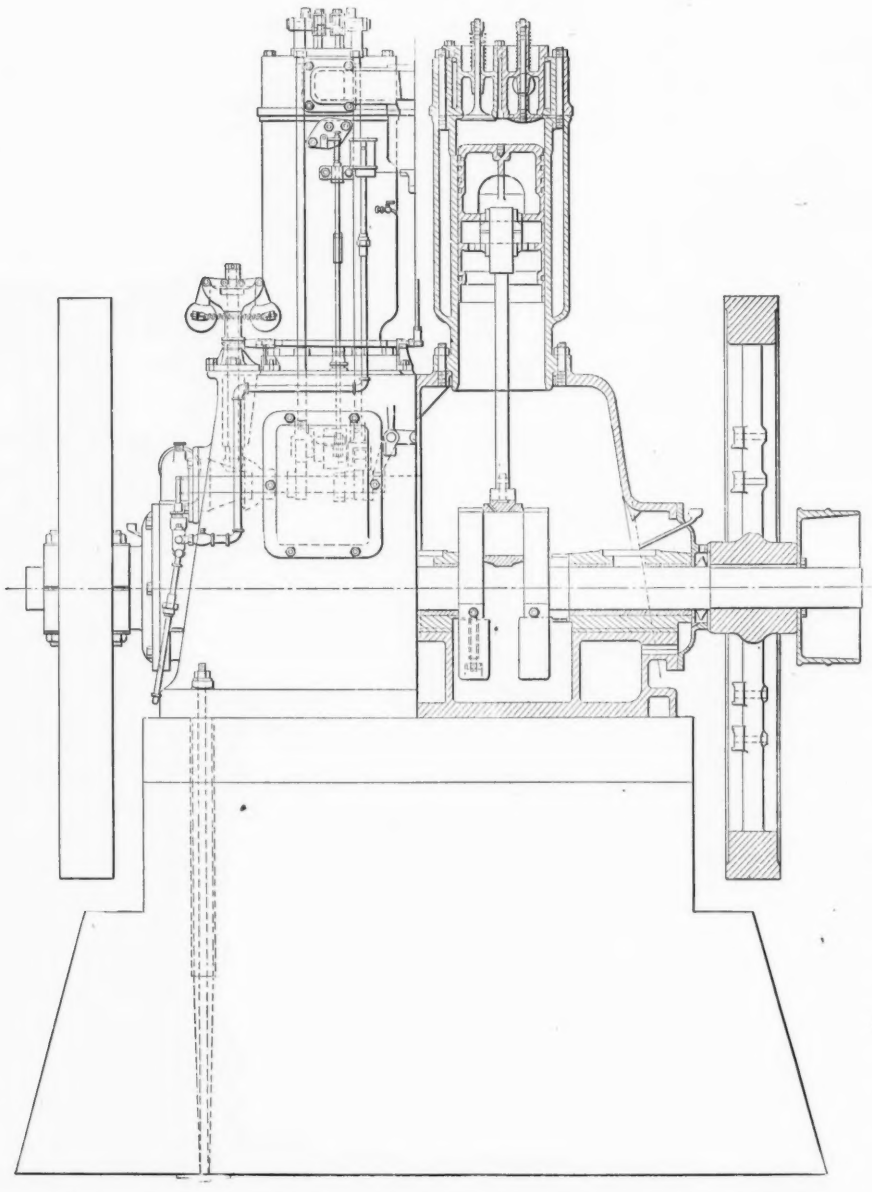


FIG. 5. SECTIONAL VIEW OF INTERNATIONAL HARVESTER COMPANY'S GAS ENGINE

The shaft runs in three babbitted bearings set into the base and resting on flat surfaces, so that they can be easily shimmed up when necessary. Ribbed projections are cast in the crank case so that the dripping oil from the top will run into the main bearings and insure ample lubrication. The upper or wristpin box of the connecting rod is slotted out of the solid forging and has brasses with wedge adjustment. The top of the rod carries an oil pan, draining to the pin, and the lower end of the rod contains oil pockets on each side which collect the oil and carry it to the crank pin.

"Eureka" Belting

The Eureka Fire Hose Manufacturing Company, 13 Barclay street, New York City, has been at work for a number of years perfecting its "Eureka" solid-woven cotton belting, which was recently placed on the market. This belting is intended for both transmission and conveying. It is manufactured on special machinery, owned by the company, the invention of the president, B. L. Stowe.

"Eureka" belting is woven under an immense tension in one solid body and, therefore, has no plies to separate. A natural tendency of the belt in work is to form itself into a coil, adhere to the pulley and make a powerful drive. The texture of the belt allows of the escape of air between the pulley and the belt. It is made treated and untreated. Treated belt will stand moisture and climatic changes, and both styles are so solidly put together that what stretch is necessarily left in the belting is minimized, avoiding the necessity of tighteners and annoying delays in taking up.

Removal of Oil and Grease from Boiler Feed Water

By Arthur E. Krause

Among the many problems with which steam users, managers of power plants, ice manufacturers and others have to contend, and have always been attempting to solve, that of completely removing the oil or grease from condensation water has probably been the most baffling and difficult, particularly that portion of it which is in the finely emulsified state indicated by the cloudy or milky appearance of the water.

This emulsion is caused by the churning of the mixture of condensed steam and lubricating oil in the steam-engine or steam-pump cylinder. It passes out with the exhaust and is found in the hotwell water resulting from the condensation of the steam. Attempts to remove the oil sufficiently to make a safe boiler water by means of separators in the exhaust line have been successful only at so much expense, uncertainty and vigilance that many stations reject the water from surface condensers and purchase city water at enormous costs.

Coarser particles or drops of oil which have not been emulsified or gone into the milky condition can be readily removed by either skimming tanks or coarse filtration through hay, excelsior, turkish toweling, terry cloth, etc. It will be found, however, that no matter how fine the filtering material has been, the milky appearance of the water caused by the oil has not appreciably changed, showing that considerable quantities of oil are still retained and leaving it unfit for ice making, boiler feeding or other purposes where a clear and pure water is the most important consideration. As long as this cloudy appearance remains, the water will be unsafe for boiler feed and will sooner or later be sure to result in serious trouble.

It may also be mentioned that by the use of coagulants and chemicals involving reactions of various kinds, the oil and milky appearance of such water may be removed, but any chemical treatment which

necessarily leaves in solution many substances deleterious for ice manufacturing or boiler purposes cannot be recommended nor trusted by careful engineers, owing chiefly to the well known harmful effects of chemicals upon the valves, boiler plates and brass fittings.

In consequence of this, oily condensation water in large quantities in power plants, ice plants and other industrial establishments is now run to waste, which, if the oil were completely removed, would be ideal water for boiler feeding, ice making and many other purposes, and which, if saved, would result in considerable economy, particularly in cities where water rates are high, and on shipboard, where special evaporators must be used to obtain pure water.

In seeking some suitable substance that would clear this condensation water completely, and without chemical treatment with its attendant evils, the writer has discovered among the magnesian products of serpentine quarries a peculiar fibrous sand which is practically insoluble and, by reason of its extraordinary physical property of attracting and retaining the oily matter in condensation water, is eminently fitted and suited to remove the last traces of oil from the latter. Its strong physical property of attracting greasy matter may be judged by the fact that the material will retain or absorb from 50 to 100 per cent. of its own weight of emulsified oil from the water after the coarser oil particles have been removed.

That this method of purifying or freeing water from oil or grease is a purely physical and not a chemical one is shown by the fact that by suitable solvents the oil can be readily removed from the spent fibrous magnesian filtering material, and the oil so obtained may be used over again for lubricating, etc.

The process, which is patented, and which is now being introduced, requires no more care than an ordinary sand filter, needs no expert attendance and is continuous in operation, the only special requirements being a pressure pump of the requisite capacity.

An additional advantage of this process is that by passing through the serpentine fiber or material the effects of the free sulphuric and other acids found in certain streams and brooks throughout the coal regions become neutralized and the water rendered entirely safe and serviceable for boiler use.

I have also discovered that this serpentine waste or fibrous serpentine sand has the property of removing the coloring matter and peaty substances contained in many well and other waters when these are filtered through or otherwise brought in contact with the before-mentioned material.

The apparatus for this process is manufactured by Alexander Miller & Brother, Jersey City, N. J.

A New Pipe Joint Cement

The H. W. Johns-Manville Company, of New York, recently placed on the market what is known as "H-O" pipe-joint cement. This cement is put up in powder form and can be kept in stock indefinitely, as it does not dry out or deteriorate, it is claimed. To use the cement it may be mixed with water or linseed oil.

The chemical properties of "H-O" cement are said to be such that it expands after the joint is made up, thereby making a perfectly tight joint. It does not harden and the joint made with it can be easily broken at any time without danger of breaking the fittings. It is not poisonous.

Water Power in Tasmania

Consul Henry D. Baker, of Hobart, Australia, reports that there is considerable agitation at present in Tasmania for governmental aid for the development of the large water-power resources of that island. The premier of Tasmania said that the difficulty is to induce capitalists and companies to utilize the power if it were developed. The cost of such works would be hundreds of thousands of pounds (£1 = $4.86). The government only required some guarantee that the power would be utilized if made available, and it would be willing to go ahead in the matter.

At present the only water-power development in Tasmania is at the city of Launceston, where for thirteen years a portion of the water power available in the South Esk river has been used by the municipality for the electric lighting of the city. The power station is about two miles from the city and the machinery comprises four three-phase generators and turbines of 450 horsepower each. In the city there are over thirty miles of streets lighted by electric lamps, and business places and private houses use the electric light largely. Electricity is also used for motors and heating appliances. The municipal council of Launceston has so far spent over $800,000 in constructive work.

No state in Australia has such abundant water power as tasmania, but as yet, however, there has been no systematic investigation, either by the government or by private persons, as to the cost of developing most of this power, or as to whether or not the power could be produced in sufficient amount, at all seasons of the year and cheaply enough, so that it would pay manufacturers to carry on industries of considerable importance in Tasmania in competition with those of the mainland of Australia.

The interior of Tasmania is mostly 1500 to 2000 feet above sea level. The moisture-laden clouds from the northwest discharge most of their contents on the first highlands they meet. In the northwestern part of this plateau there are a number of large lakes, the four principal ones being St. Clair, Echo, Great lake and Lake Sorell. In the northwestern part of this lake country the rainfall is said to average 84 inches, but at the southeastern end only about 35 inches. Any successful power plant, therefore, would probably necessarily be located in the northwestern part of the lake region. It has been roughly estimated that from Lake St. Clair could be produced a minimum of 46,000 horsepower, from Lake Echo 9000 horsepower, and from Great lake 27,000 horsepower, a total of 82,000 actual horsepower. These three lakes are from 2000 to over 3000 feet above sea level, and natural reservoirs.

As it is probable that the power could not be profitably utilized at the different power stations which might be constructed in the lake region, the power would have to be transferred to places where it is required.

In case it should be possible to make Hobart the manufacturing center of Australia, among other reasons, on account of her facilities in producing inexpensive and reliable power, the 82,000 horsepower at the different power stations in the lake region would be reduced by about 30 per cent. (namely, by converting the mechanical energy into electric force, by friction and loss on line from power stations to Hobart, and by reconverting the electric current into mechanical energy), and the power which could be distributed at Hobart would be, say, 57,000 actual horsepower.

At present not 1000 horsepower is consumed in Hobart for tram service and for lighting, but if it be a true maxim that "supply creates demand," and if an inexpensive and plentiful supply of electric force were offered here the demand would increase; perhaps, under such conditions, Hobart itself might absorb from 5000 to 7000 horsepower, and 50,000 horsepower would be available for large manufacturing industries.—*Consular and Trade Reports.*

Enlarging a Central Station

The Oliver central power station, Pittsburg, Penn., is being entirely rebuilt and greatly enlarged to handle the increased load. William Boyle, who has had charge since the plant was first installed, retired February 1, going into business for himself as consulting heating and ventilating engineer, but is supervising the completion of the Oliver plant. The operation of the power house and maintenance of the estate are now in charge of Cadwallader Evans, Jr., formerly with the Oliver Iron and Steel Company, and once superintendent of the Blaine Coal Company.

Some Useful Homemade Apparatus

By R. O. Richards

A few months ago I received a letter from the manager of a small plant, under whom I once was employed, requesting me to devote my spare time to aiding his engineer to remodel the steam plant. Besides installing some fuel-saving auxiliaries and simplifyng the piping system, which was in such an intricate state that it could be likened only to a lot of snarled fishing lines, we introduced some novel apparatus and methods of our own.

To distinguish the different steam pipes and valves we had several pipe-covering bands painted various bright colors (a suggestion obtained from Power), and these were secured to the pipes at every turn, in each side of such walls as the pipes penetrated and on each side of every valve. We found, however, that these were distinguishable only in the daytime, the night watchman discovering that all colors looked alike to him. To overcome this obstacle, each valve was given a number, which was painted on a glass tag framed with tin. A card was hung in the engine room, showing the location, color and number of each valve.

A card system for keeping track of all work done was also introduced (another suggestion from Power). Thus, one card would tell how often the pump valves were renewed, another would show how long the rod packing lasted, etc. Then, when the drummer came around, the engineer would show him a record of his wares, and if a disgruntled salesman went to the office and hinted that the engineer must be accepting graft from a competitor, the "old man" knew better, for the records were always accessible.

This plant is situated near the retail section of the town, and we were up against the smoke question. Provided the fireman stoked according to instructions, we feared no smoke inspector, but —well, I guess we have all been up against these conditions. Moreover, we were troubled with lack of draft. A request for stokers was turned down at the office, on the ground that if we could sometimes fire for a whole day without producing smoke, the management failed to see why we could not always fire that way (there is a moral here for firemen). They were, however, willing to have a fan installed, and this gave me a chance to try a certain form of furnace that I often thought would at least be handy, if not economical.

A New Type of Furnace

After seven months' constant use, I am beginning to feel proud of it, and as I have not seen anything similar to it, a short description follows. The reader will bear in mind that this is a small plant consisting of one 72-inch and one 60-inch return-tubular boilers. The plan was to use forced and natural draft at one and the same time. Fig. 1 gives a good idea of it. It will be noticed that two one-brick-width walls divide the ashpit into three parts. The jog in the sidewalls of the furnace is such as to admit of one extra grate bar on each side. The letters *F D* stand for "forced draft" and *N D* for "natural draft."

Green coal is thrown on the grate subject to the forced draft. After coking, it is spread over the natural-draft grate. Barring and spreading is done through the small door *A*. The opening is just large enough to admit the free handling of the bars, and is so constructed as to form a hump to act as fulcrum, thus greatly facilitating the throwing over of the caked coal. Sections through one of the castings forming the bar doors are shown in Fig. 2. With the improved draft and the greater grate surface, the engineer is able to dispense with one boiler and not have to force the one in use unduly. The fireman, believing that the method of stoking produced this result, religiously adhered to instructions. Indeed, he has to, for I have never yet seen a furnace that will stand less monkeying with.

The forced draft is at no time objectionable, having but a slight tendency outward when the furnace doors are opened—just sufficient to prevent the inrush of cold air while coaling. Control of the forced draft is obtained by connecting the balanced throttle valve of the fore engine to the cord of the regulator, the fore engine being made, however, to close ahead of the damper. There are also the usual hand dampers in the ashpit. Fig. 2 shows the manner of clearing the forced-draft grate The bars are raised and lowered by the chains shown and manipulated by a handwheel at the side of the boiler. The necessary extras were made and attached to a common "hoo-hoo" grate by ourselves. The chains are used only while the boiler is being fired, the regular cleaning being done through the large doors in the usual manner.

A phenomenon of this furnace is that when the forced-draft grate is properly coaled, the natural draft exerts itself sufficiently to keep steam up; but when the green coal is caked the forced draft seems to kill the natural draft. This works advantageously, as the fireman is compelled to fire just so, for, unless the

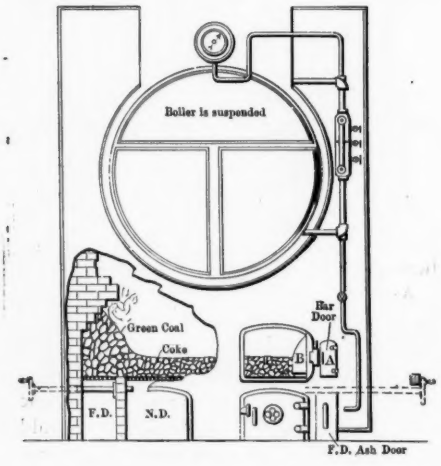


FIG. 1. SPECIAL TYPE OF FURNACE

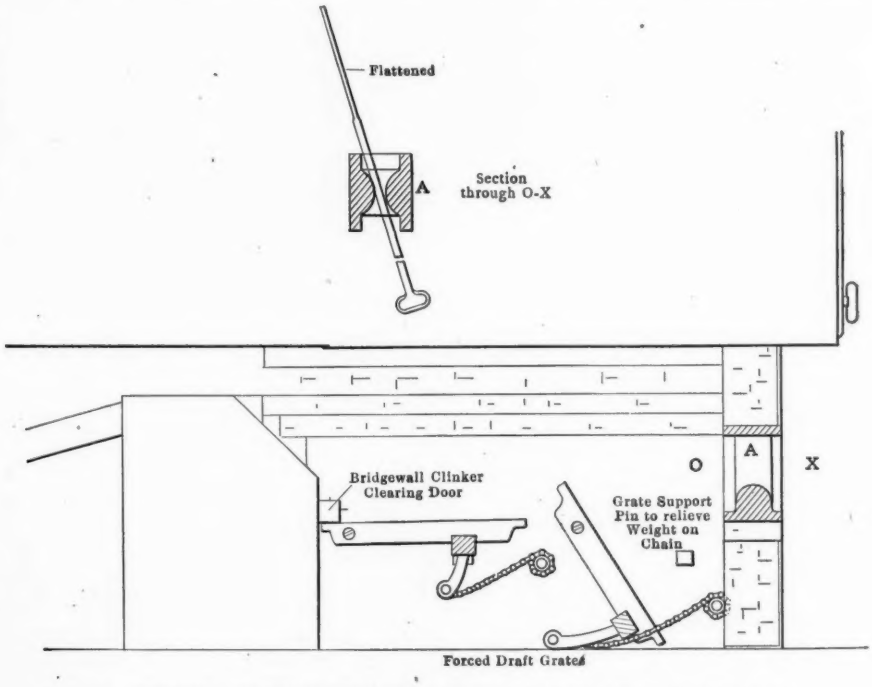


FIG. 2. SHOWING SECTIONS THROUGH CASTING FORMING THE BAR DOOR, ETC.

natural-draft grate is covered with good live smoke-consuming coke, the steam pressure will drop and any attempt to put on green coal (which would produce smoke) is paralyzed by the extra work required to keep the steam up. If, however, the firing is done according to instructions, no difficulty is experienced.

Two tons of coal is burned per ten hours. The evaporation per pound of coal is 8.39 pounds, as against 8.11 pounds previously. The design of the furnace could easily have been improved, but we had to bear in mind that should it not be a success we would have to restore it in a very short time to prevent a shutdown. All that is necessary is to break down the dividing walls in the ash-pit and either natural or forced draft may be used under the whole furnace.

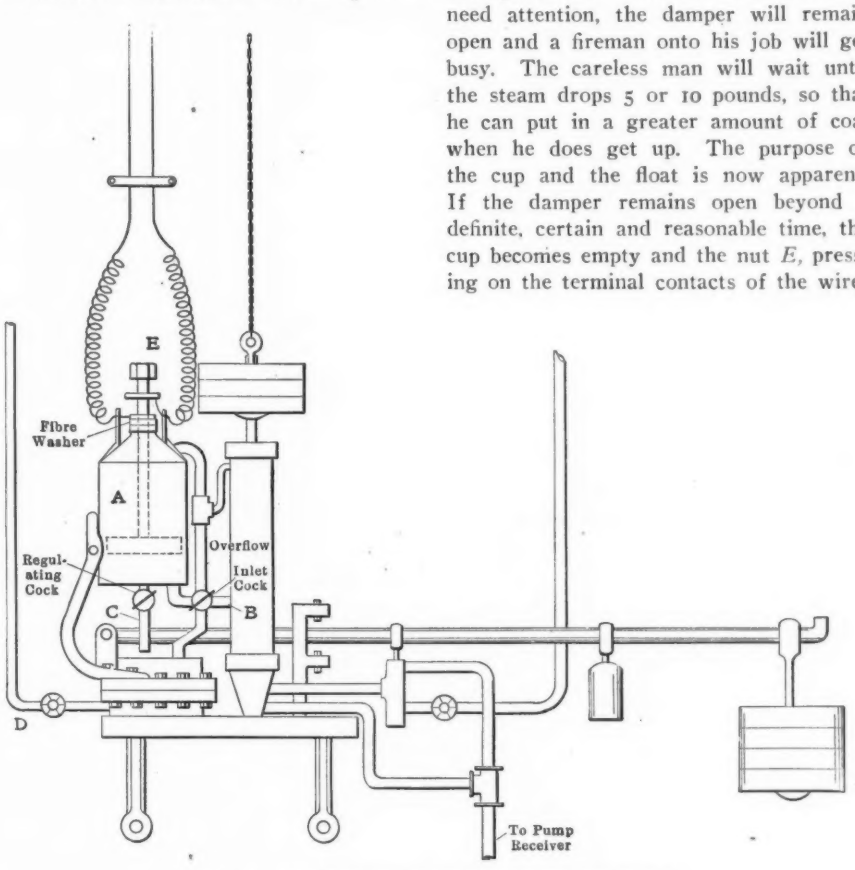


FIG. 3. SHOWING HYDRAULIC DAMPER REGULATOR

Hydraulic Damper Regulator

The writer believes that the only place left to practice economy is in the boiler room. A great variety of expensive devices are in use to save 2 or 3 per cent., while the fireman has a free hand to waste 10, 15 or even 20 per cent. of the coal pile. Therefore, an engineer is justified in installing anything that will *compel* his fireman to do his duty with due regard to economy. Such devices may be an insult to a good man, but good firemen are rare articles—somehow they quickly climb up to the engine room.

There is provided a cast-iron air-cooled plate which makes it necessary to keep the dead plate clear. Fig. 3 shows an hydraulic damper regulator to which is attached the cup *A*. When the piston of the upright hydraulic cylinder rises, water enters the small pipe *B* and flows into the cup, from which it trickles through the pipe *C*. When the damper is wide open and water is automatically shut off from entering the cup, the regulating cock *D* is so set that it takes a certain definite time to empty the cup.

We all know that with the fires in good condition, with no air holes in them, the damper will be continually playing from open to shut, unless the boiler is unduly forced. When, however, they need attention, the damper will remain open and a fireman onto his job will get busy. The careless man will wait until the steam drops 5 or 10 pounds, so that he can put in a greater amount of coal when he does get up. The purpose of the cup and the float is now apparent. If the damper remains open beyond a definite, certain and reasonable time, the cup becomes empty and the nut *E*, pressing on the terminal contacts of the wires shown, causes the ringing of a bell, which will or should bring the wise engineer to the boiler room.

Discretion must be exercised, of course, and every ringing of the bell should not merit a call down, but when it begins to work overtime don't expect to reach that best evaporative record. Maybe this device has something to do with the success of the furnace described, for the fireman seems very anxious not to have that bell ringing. One thing I am sure of, it has certainly made a good man of him.

A Blowoff Telltale

Another fertile source of loss of good B.t.u. by a careless fireman in a small plant is in letting the water in the boiler get too high, necessitating a hasty, often clandestine, visit to the blowoff valve.

From a record kept by the engineer, after we had installed the device shown in Fig. 4, it was found that the blowoff valve had been opened four times in twenty-four hours, and at no time had it been opened wide. How much good boiling water went out this way, and how much scale there was back of the valve, that could not pass through the limited opening but was gradually working its way under the valve seat, would be difficult to estimate. The device shown (Fig. 4) would tell us (1) how often the blowoff valve was opened (2) if it was opened wide (3) the time it was opened (4) if opened wide, the approximate amount of water blown out (5) the pressure at the time.

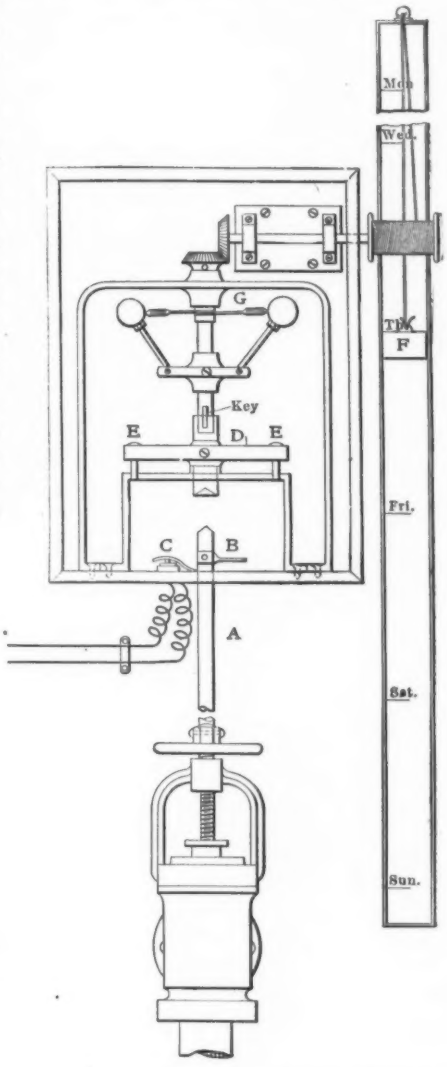


FIG. 4. DEVICE TO "KEEP TABS" ON THE BLOWOFF

The thing is extremely simple and easily made. Referring to the sketch, it will be seen that an extension rod *A* is securely pinned to the blowoff-valve stem. This enters the box shown, the cover of which has been removed. A piece of stiff hoop iron is attached at *B*, and at *C*

is a watchman's pushbutton, which connects with a needle in the magneto clock. It is evident that the blowoff valve cannot be opened even halfway without pushing the button, thus the time the boiler is blown down is read from the paper dial, and the pressure at that particular time is obtained from the recording steam-pressure gage.

Those not possessing a pressure-recording gage may easily fix a needle point to the finger of a small gage in such manner that the projection *B* will cause the needle to punch a strip of paper placed under it. The position of the punch mark will show the pressure at the time the blowoff valve was opened. When the blowoff valve is wide open the extension rod *A* will come in contact with and raise a small casting *D* which is free to slide along the spindle of the governor shown. This will release the stop pins *E* and the weight *F* connected to the governor by the cord-and-miter gears shown and start it revolving.

It is evident that without something to retard the downward moton of the weight *F* the mechanism would have to be wound up daily. So, connecting the governor balls and supporting them, with one turn around the stationary guide, is the stout cord *G*. It was found to work better by putting a light spring on each side in series with the cord. A small tube is provided in the cover of the box to carry a drop of oil once in awhile to this cord. By marking on the long board to the right distances equal to the daily travel of the weight *F*, when, say, a gage of water is blown out, we would very nearly determine the actual quantity of water that left the boiler via the blowoff valve. The weight *F* should be boxed in and the cover locked, for if open the operator is liable to watch the descent of the weight, instead of watching the water in the gage column. These automatic affairs are liable to get out of order.

Apparatus to Control the Power Pump

For boiler feeding we had a duplex steam pump and a belt-driven power pump of the crank and crosshead type. Of these the power pump was preferred, and to control it was built the apparatus shown in Fig. 5, which was installed in a conspicuous but out of the way corner in the boiler room. On the flanges of the base elbows shown are the diaphragms *A*. Resting on the right-hand one on a suitable lever are the weights *B*; on the other rests the stem of the 2½-inch valve *C* on the suction line of the pump. The thread by which this valve is ordinarily operated is removed and the stem neatly bushed, so that it opens and shuts with a sliding motion.

Between the two diaphragms is a solid body of water, so that any movement of one diaphragm causes a corresponding movement in the other. The weights *B* balance a certain hight of water in the apparatus, as shown by the gage glass. When this hight is exceeded, the valve diaphragm *A* is depressed and valve *C* will consequently open. It was found, however, that this was not quite sensitive enough, so the float shown in the cut (and taken from an old steam trap) was added to balance the weight of the valve stem and disk. On top of the receiver will be seen in section a small cylinder, the pistons *D* of which connect by the levers shown to the diaphragm weight lever *B*, so that any fluctuations in the hight (weight) of the water in the receiver will cause a reciprocating movement of the pistons *D*. Between the two pistons a certain water pressure is maintained by the small pipe shown, which connects with a common float tank stationed near the roof. In the position shown this pressure is also maintained in the pipe *E* which, as clearly shown in small sketch, leads into another small cylinder *F*, causing the piston contained therein to shift the belt onto the loose pulley.

In the same manner, when the pistons *D* move upward, the pipe *G* will then be under pressure, and as it connects with the cylinder *G* the belt is shifted to the tight pulley, while the water in cylinder *F* is now free to empty into the receiver. The quantity of feed water is, as in all other pump receivers, governed by the cold-water valve *L*.

Pump controlling, however, is only one of the many uses of this apparatus. For instance, it would immediately tell when one of the steam traps leaked, for then no water would show in the glass, and the weight lever *B* would be up against the stop *H*. Thus it becomes an excellent means of "keeping tabs" on the steam traps. When a trap leaked, the vent was opened, until that trap could be bypassed and fixed. Again, we could tell exactly how much steam any live-steam apparatus in the plant was consuming by weighing the water of condensation as drawn out through the valve *K;* we could get a fair idea of the efficiency of our pipe covering, and the highest water level that could be carried in the boilers and still furnish dry steam. We even have disconnected it and used it to condense the exhaust from the fan engine, air pump and tank pump to find the actual amount of steam consumed by these appurtenances. For this purpose is the spray plate shown. Any back pressure could be maintained in the receiver by shifting the weights *B*, piping a gage at *M* and careful manipulation of the cold-water valve.

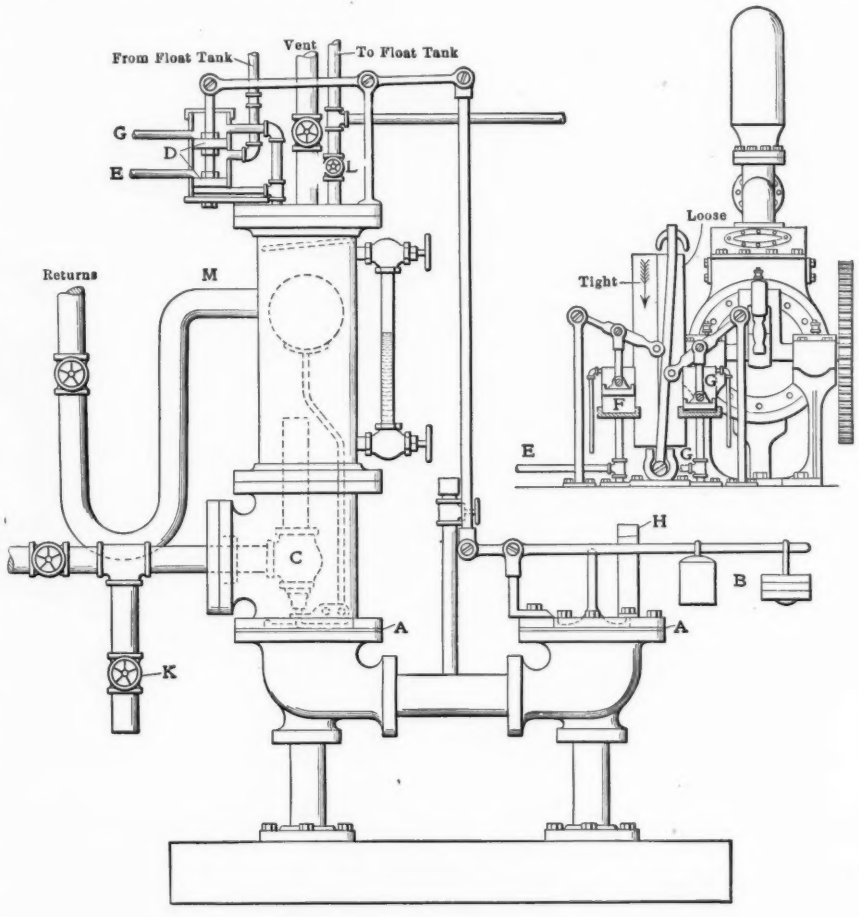


FIG. 5. APPARATUS FOR CONTROL OF THE POWER PUMP

Potblyn, P. D.

By John Watson

"Say! I believe she put him up to it, don't you?" I had been so deep in a series of calculations that I had not heard my office door open, and the above query was the first intimation that I had of the "Doc's" presence. I swung around in my chair, put down my slide rule and pushed back my papers, as an indication that I was a willing listener.

The "Doc" had just returned from a trip South and I was anxious to hear about the results of his surgery. I knew that he had performed a successful operation, for the smile on his face was that kind of a smile. He had three kinds of smile and I had learned to recognize them. When he was contented with himself, the world in general and yesterday's baseball scores, he wore one kind of a smile and was a very agreeable sort of a chap. If things were going sort of crosswise, he grumbled and swore a lot in a half good-natured sort of way. If he thought that a man had not used him right, and he was "mad" clear through, he also smiled, but it was a still different sort of smile, and at such times it was well to let him alone. The gage indicated fair weather this time, so I settled back in my chair to listen to his tale. Of course it was some time before we reached the point, for the "Doc" had first to discuss the news of the day and a prizefight or a murder case was even more interesting to him than the baseball scores. The recent murder in New York, where a girl was held as accomplice of the man on trial, held the floor until we had clearly proved her to be guilty and then we could take up the pump problem.

"Well, 'Doc,' what was the matter with it anyway? Was it the suction pipe this time?"

"Doc" grinned at the reference to his hobby, for it was well known that just as some M.D.'s always diagnose any kind of a stomachache as appendicitis, especially if the patient has money, so Potblyn, P.D., usually started out on a case with the firm conviction that the suction pipe leaked. It was astonishing the number of cases that he had operated on for leaky suction pipe and effected permanent cures.

"Naw! It wasn't the suction pipe this time, but the darned thing leaked, though, and needed fixing just the same."

Having got a fair start the "Doc" proceeded to tell his story about as follows:

"Say! Of all the complication of diseases you ever heard of, this pump had 'em all a goin', and had me a goin' for a while, too. You remember the trouble don't you? Old 'Whiskers' wrote you all about it. Say! You don't know old 'Whiskers,' do you, except by his letters? You ought to see him—made of odds and ends and got the 'Yaller Kid' and 'Happy Hooligan' beat for first money. Gee! but I had to laugh when I saw him. Didn't look as if he knew enough to pound sand into a rat hole. Well he took me out back into the woods where the pumps are located. They've got two little compound duplex direct-actin' pumps, just alike. One ran slick as grease, you couldn't ask for anything better. The other fellar, right side of it and just like it, was knocking to beat the New York *Sun*.

"Opportunity knocks but once, but this darn thing had opportunity left at the post, for it was knockin' seventy-five to eighty times a minute right along. Old 'Whiskers' was discouraged and felt like doing a little knockin' on his own hook. First look out the corner of my eye, I seen they had separate suction pipes—and I put on my 'Gosh! this is easy' kind of a smile; but, say, that wouldn't do for 'Quaker Oats,' for it came off—way off—before I got the blamed thing fixed.

"I let 'er run awhile and I loafed around the engine and boiler rooms rubber-neckin' the place and lookin' wise. I finally see the old goat was gettin' nervous because I didn't do something, so I got into my warpaint and started to imitate a man getting busy. I shut her down and looked over the water end. The valves were in pretty good shape; I guess you wrote him to make sure that they were all right. Then I tested out the suction pipe; lucky there wasn't as much of it buried as there was on that job up in Massachusetts. I found several leaks but they were small ones and didn't amount to much.

"Next, I tried the air chamber and found it solid full of water. No wonder she pounded. I put on an air-chargin' rig and a glass gage and thought that I had things all fixed and my job done. We started up again and got the air chamber full of air, and about then your uncle began to get interested in the game, for while the heavy pound had disappeared there was still a decidedly hard knock that seemed to be in the steam end.

"I knew that the water end was all right, so I shut 'er down and as soon as she had cooled off a bit I opened up the steam end. It seemed to be the left-hand side that was thumpin', so I opened up the right-hand side first, just to be sure not to miss anything, as I wanted to make a complete job of it this time. I looked over both the high- and low-pressure pistons and found them all right. Then I opened up the left-hand side and found the low-pressure piston loose on the rod. 'Check,' says I, and I called 'Whiskers' over to show him where the trouble was. He was so pleased to have found the trouble that he gave me a cigar. Say! I was as badly fooled on that cigar as I was on the pump. He handed it out to me with the regulation two-for-a-quarter wave, instead of shovin' it at me like a three-fer-five.

"I fixed the piston, closed the cylinder and told the engineer to start up. I was through. I lit my cigar and started to get my overalls off. Biff! an uppercut right in the jaw. I felt as if I had got one when that pump started out just the same as ever—biff, bang, every stroke; gosh, it was enough to make a perfect lady mad. Two operations and no cure. 'Whiskers' probably wished he had kept his cigar; so did I, for by this time I was looking for a chance to lose it.

"It was getting late, so we concluded to wait until mornin' before investigating further. I've seen the time when I would have lain awake a long time worrying over a job like that, but I'm too old for that now and, besides, I had a card or two up my sleeve to play in the mornin' when the game opened. I can't say much for the hotel in that measly town. The soap in my room wasn't worth bringin' away. The darndest lot of loafers around there, they think 'Fitz' is all in and hasn't got any fight left in him. What's the use of talkin' to fellers like that? I couldn't convince them of nothin'.

"Old 'Whiskers' was on deck bright and early in the mornin'—darn these country habits anyway—and we went back on the job. I had concluded that there was too much power somewhere that made her hit the heads, and first off I had a look for my old enemy, cross-exhaust. Nothin' doin'. Then I opened up the steam chests and had a look. Once more I smiled but this time I kept quiet; I didn't want any more cigars. Say! I wish I'd brought you one of those just for luck.

"Well, there was the left-hand high-pressure valve cocked up and one side of it ridin' on the guide so that that side was three-eighths to one-half an inch off the face and the steam had a chance to blow right through into the low-pressure chest. That side was runnin' high pressure, while the other side was runnin' compound. No wonder the poor old gal had the spring halt.

"I slipped the valve back into place, closed her up again and started off once more. By Tokey, if she didn't still knock. It wasn't quite as bad as before, but the knock was still there, with the bells on. Up to this time it had been sort of plain sailin' lookin' for the usual things, in the usual places, and applyin' the usual plasters. Things were beginnin' to look interesting and I didn't just know what to look for next.

"I opened up the whole steam end and looked it over carefully. Then I had the engineer travel the pump while the heads and covers were off and I watched the

pistons and valves, one at a time, to see that they were all right and fitted throughout the full stroke. In this way I discovered that the same old high-pressure valve cocked up on one end and allowed steam to blow through. Looking for the cause I found that the valve rod was bent between the high- and low-pressure chests. Evidently somebody had dropped a carload of freight on to it but, of course, they wouldn't investigate to see if a little thing like that had damaged the pump in any way.

"Well, I took out the valve rod, straightened it, made sure that the valve seated properly and then closed her up and started again. Knocked out in the fourth round—I had got her fixed for keeps this time and she ran as smooth and slick as could be. I tell you I felt somewhat relieved, for, after the way things had been goin' I didn't know what might show up next.

"Pumps are as bad as kids. When they get cantankerous it is safe to expect most anything and some pumps, like some kids, seem to ketch everything there is goin', and no reason for it, either. Old 'Whiskers' was pretty well pleased and thought I was quite a fellar. I guess he will get along all right, now, without any more trouble, but say, you fellars ought to put gage glasses on all of your air chambers.

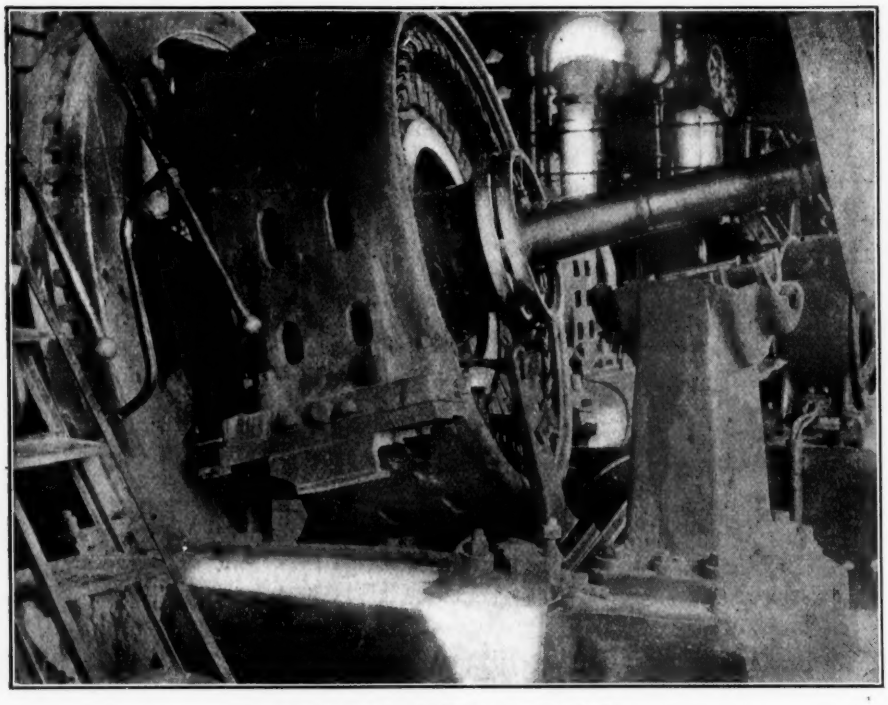
"What good is an air chamber full of water? They'll fill up sure as preachin' and how is a man goin' to know how they stand unless you put a gage on? What's the use of being a tightwad? Loosen up a little, give a fellar something for his money and when you send out an air chamber send a gage glass with it."

With this parting advice the "Doc" departed for the shop. I had hardly turned to my work again when he opened the door, just enough to stick his head through, and remarked.

"Say! I wish you could see 'Whiskers,' he's a peach."

Broken Shaft Wrecked Engine and Generator

The accompanying illustration depicts the wreck due to the breaking of the main shaft of a 440-ampere generator at its center bearing. It will be seen that the frame supporting the generator field is broken, also that the top of the outer pillar block was wrenched in pieces. The real cause of the accident is not known,



WRECK DUE TO BREAKING OF SHAFT

but it is supposed to have been due to a flaw in the shaft. No one was hurt, but the engine was entirely wrecked and almost a total loss.

Boiler Specifications

We design a large number of horizontal tubular boilers for our assured and patrons, giving them the benefit of the wide experience of our steam-engineering experts. These specifications are, of course, unprejudiced, and the boilers designed by us can be readily built by any modern shop. We have not, for several years, designed a boiler using a lap-joint, double-riveted, horizontal seam. We have been fully aware of its inherent weakness. We have had no difficulty whatever in convincing our patrons of the superiority of the butt joint as against the lap joint. Some recent disastrous explosions due to the lap-joint type of boiler indicate that our view is sound.

In the standard butt joint, the net section of the plate between the rivet holes is the weakest part, although this runs theoretically from 84 to 94 per cent. of the solid plate. In practice, however, with ordinary punched rivet holes, due allowance should be made for the injurious effect of the punch on the plate, and this is an unknown quantity. All authorities agree that the metal is injured, but differ as to the extent. Various experiments show, however, that the injury increases with the thickness of the metal.

If the rivet holes be drilled full size in flat plate, we would have the usual bend strain between the rivet holes when the plate was being rolled up. On the other hand, if the rivet holes in plates ½ inch and under are punched ¼ inch below size, we have more metal to resist the bend when rolling. Bearing this in mind, together with the injury done by punching, we have adopted the rule of calling for all rivet holes to be punched ¼ inch below size, then the plate to be rolled up, assembled and the holes reamed out to full size, thus removing the evil effects of the punching and having the rivet holes in perfect alinement. The reaming of the holes is today done with pneumatic tools, and is a simple, cheap and rapid operation. This change has received the approval of several authorities and commends itself to every thoughtful engineer as far better than the common practice of reaming the hole 1/16 or ⅛ inch.

In this connection it is well to note the increase in sizes of horizontal tubular boilers. A few years ago a 60-inch shell was called a large boiler, while today the larger per cent. of the boilers being installed are 72 inches by 16 to 18 feet in length, practically doubling in capacity the 60-inch size. It is also true that the evaporation per square foot of heating surface has been increased, when soft coal is used, by artificial drafts, mechanical stokers, etc. With the heavier plate used in the large sizes of shells, greater care must be observed in keeping the boiler free from scale, grease and deposits of sediment, and all appliances must be in the best of order.—Fidelity and Casualty Company's *Bulletin.*

Personal

Harry J. Marks, formerly mechanical engineer of the Empire State Engineering Company, has become associated with Edward P. Hampson, 170 Broadway, New York City, in a general engineering business, including the handling of a line of engines and boilers and making a specialty of the American Ball angle-compounds.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Safe Speed for Cast-iron Flywheels

I have an engine running at 250 revolutions per minute and I should like to know if it is safe to increase the speed to 300 revolutions, the flywheel being 78 inches in diameter?

W. A. L.

With cast-iron flywheels a rim speed of 90 feet per second should not be exceeded. At 300 revolutions per minute the rim speed of a 78-inch wheel would be more than 102 feet per second and manifestly unsafe. A cast-iron wheel running at 300 revolutions per minute should not be more than 66 inches in diameter.

Windings for Choke Coils

Is there a simple rule for determining the winding for a "choke" or reactance coil?

A. P. K.

Two rules are necessary, one for the size of wire and the other for the number of turns in the coil. To ascertain the size of wire, multiply the current to be carried by 1500; the result will be the cross-section of the wire in circular mils. To ascertain the number of turns required, multiply the desired counterelectromotive force by 13, for 60-cycle current, or by 9 for 125-cycle current, and divide the result by the cross-sectional area of the core measured in square inches.

EXAMPLE: A core having 1 square inch cross-sectional area is to be wound for a counterelectromotive force of 40 volts, at 60 cycles frequency, and the wire must be large enough to carry 10 amperes without overheating.

To carry 10 amperes, the cross-section of the wire must be not less than

$$10 \times 1500 = 15{,}000$$

circular mils. No. 8 is the nearest commercial size, its cross-section being 16,510 circular mils. To give an electromotive force of 40 volts, at 60 cycles, the number of turns must be not less than

$$\frac{13 \times 40}{1} = 520.$$

The disposition of these 520 turns will depend on the length of the available coil space along the core; the coil should occupy the full length of the space, leaving its thickness to come as it may.

Large Engines, Steam and Gas

Please tell me the rated horsepower and dimensions of the George H. Corliss engine used by the Pullman Car Company, Pullman, Ill. Also, what is the largest single unit in the world, steam or gas, used for the generation of power?

E. J. R.

The horsepower of the Corliss engine at the Pullman works is 2400, the steam pressure 40 pounds and the revolutions per minute, 36. The dimensions are: Cylinder diameter, 40 feet; stroke, 10 feet; piston rod, 6¼ inches in diameter; connecting rod, 25 feet long; bearings, 18x24 inches; walking beam (web), 25 feet long; flywheel, 56 tons, 29.7 feet in diameter, 24-inch face, 216 teeth with 5⅛-inch pitch. The largest stationary steam engine or power generator is the Manhattan engine. The largest steam turbines are those in the Commonwealth Edison Company's station in Chicago. They are rated at 14,000 kilowatts maximum continuous load. The largest gas engines for power purposes are the engines built by the Snow Steam Pump Company for the California Gas and Power Company. The cylinders are 42x60, and the engine runs at 88 revolutions per minute. A larger cylinder is 44x54 inches, but it does not deliver as much power as the Snow engine, as the revolutions per minute are 83⅓ and the gas used is of much lower heat value.

It is understood that there is a gas cylinder 52x55, single-acting, developing 700 brake horsepower at 90 revolutions per minute with furnace gas, but this unit is in Germany. The largest engine known in this country is a 25,000-horsepower rolling-mill engine at South Sharon, Penn., at the Carnegie Steel Company's plant. The frames and slides are cast in one piece and weigh 118 tons. The total engine weighs 550 tons. This is a horizontal twin tandem rolling-mill engine, with cylinders 42 and 70 by 54, to operate with 175 pounds of steam, condensing, at from 150 to 200 revolutions per minute, developing its maximum power at the highest number of revolutions.

Book Reviews

MECHANICAL WORLD ELECTRICAL POCKET BOOK. Published by Emmott & Co., Ltd., Manchester, Eng. Cloth; 278 pages 4x6 inches; illustrated; many tables. Price, 8 pence, postpaid.

The 1909 edition is considerably more comprehensive than the previous one. The topical scope now includes transformers, rotary converters, motor generators, three-wire balancers, boosters and electric elevators. The discussions, however, are brief to the verge of perfunctory scantiness.

MECHANICAL WORLD POCKET DIARY AND YEAR BOOK. Published by Emmott & Co., Ltd., Manchester, Eng. Cloth; 356 pages, 4x6 inches; 61 illustrations; many tables. Price, 8 pence, postpaid.

This is the twenty-second annual edition of this useful little manual, but it shows the effects of revision notwithstanding its long life. The discussion of friction clutches has been made more comprehensive; the steam-turbine section has been extended to keep abreast of recent developments, and a section devoted to chain drive has been added. The section devoted to gas power remains inadequate, as before.

THE TEMPERATURE-ENTROPY DIAGRAM. By Charles W. Berry. Published by John Wiley & Sons, New York, 1908. Cloth; 314 pages, 5x7½ inches; 109 illustrations. Price, $2.

This is the second edition of Professor Berry's excellent work, and a mere comparison of bulk would suffice to indicate extensive revision; in the present edition there are more than twice the number of pages in the first edition. The chapter on the flow of fluids has been thoroughly revised, a graphical method of projection from the pressure-volume plane to the temperature-entropy plane for perfect gases has been worked out and its application illustrated in two chapters on hot-air and gas engines; a chapter on the thermodynamics of gas and vapor mixtures has been added, and the various factors affecting the efficiency of actual gas-engine and steam-engine cylinders are discussed. For the information of those unfamiliar with the first edition it may be stated that the work is chiefly mathematical in character; the discussions are, however, correspondingly accurate and complete.

NOTES ON MECHANICAL DRAWING. Victor T. Wilson and Charles L. McMaster. Second edition. Published by Wilson & McMaster, Lansing, Mich. Cloth, 159 pages, 6x9 inches; illustrated.

Students of engineering, whether at school or engaged in home study, will find in this book nearly if not all the instructions needed by one who desires short, intelligent and concise instructions in the elements of mechanical drawing. Exercises as such for the purpose of training the hand and eye in the use of drawing instruments have been reduced to the smallest possible number, and practical problems substituted. Minute directions for every operation in the process of mechanical drawing are given, in the belief that these, if followed by the student, will give a ready grasp of the subject. Differing from the ordinary methods of textbooks on this subject, lettering is made the subject of the first chapter, which is followed by chapters on projection, straight-line drawing, curves, sections, geometrical drawing, working drawings, machine sketching and miscellaneous instruction. The chapters being few, the work is not indexed.

Books Received

"Morrison's Spring Tables." By E. R. Morrison. Morrison & Martin, Sharon, Penn. Cloth; 84 pages, 6x9 inches.

"General Lectures on Electrical Engineering." By Charles P. Steinmetz. Robson & Adee, Schenectady, N. Y. Cloth; 284 pages, 5¾x9 inches; illustrated; indexed. Price, $2.

Silk City Council Entertains

Silk City Council No. 18, Universal Craftsmen, Council of Engineers, of Paterson, N. J., held its first annual entertainment and reception at Turn hall, Paterson, on Friday evening, February 12. The engineering craft was largely represented, as well as the various Masonic lodges, there being many visitors from nearby cities. The first part of the evening was devoted to the rendition of an enjoyable entertainment, following which Past Worthy Chiefs William Brameld, F. W. Johnson and Edward Livingstone were presented handsome jewels. The grand march then took place, and dancing was enjoyed until the early morning.

The committee in charge of the arrangements comprised Edmund Whittaker, R. Templeton, E. B. Lupton, F. W. Johnson, Edward Livingstone, George Robinson, B. Chandler, C. Van Gieson, D. McHenry, R. McCullough, C. McLean, W. McDonald, J. McCullough, A. Thomas, F. W. Johnson, William Patrick, Andrew Young, M. Zocklein and Alexander Young. Robert J. Hanna was stage director. It was an especially enjoyable occasion.

Stevens Institute Alumni Dinner

The alumni of the Stevens Institute of Technology had their annual dinner on Friday, February 19, at the Hotel Astor, Broadway and Forty-fourth street, New York. There was an attendance of about 350, and great enthusiasm prevailed. The toastmaster was Henry Torrance, Jr., of the class of '90, and the speakers were President Alexander C. Humphreys, of Stevens Institute, who spoke about the institute; Alfred Noble, past-president of the American Society of Civil Engineers, and a former member of the Panama canal commission, who advocated the lock system for that great enterprise and gave an authoritative review of the whole project; Col. H. G. Prout, vice-president of the Union Switch and Signal Company, who spoke of the ethical and ideal aspects of engineering; John A. Bensel, commissioner of the Board of Water Supply of New York City, whose subject was New York's water supply; and Col. George Harvey, who wittily commented on the remarks of the preceding speakers, and in more serious vein referred to the engineering features of the Panama canal.

Business Items

The Boston branch of Charles A. Schieren Company is now located at 641 and 643 Atlantic avenue, opposite the South station. There they have a floor space of about 5500 square feet with one of the best-appointed leather stores and belting shops in Boston.

George W. Hoffman, Indianapolis, Ind., manufacturer of the United States metal polish, reports a rapidly increasing business since the first of the year. This polish has been improved and Mr. Hoffman aims to keep it the best on the market for all classes of bright work around a power plant. A free sample will be gaidly sent to any engineer upon application.

A directory of engineers and power plants of Greater New York for 1908 and 1909 has just been issued by the Engineering Directory Company, 100 Nassau street, New York City. An alphabetical list of plants is given, together with their capacity and names of engineers-in-charge; also, an alphabetical list of licensed engineers in Greater New York. The price of this directory is $10.

A new style of hot-blast heater coil, distinguished by a positive flow of steam, water of condensation and air in the natural direction due to gravity, and suitable for use with live and exhaust steam and also with water for heating or cooling purposes, was recently placed on the market by the Green Fuel Economizer Company, of Matteawan, N. Y. They advise us that they have made recent sales of this apparatus to 25 well-known concerns.

The Wm. B. Scaife & Sons Company, of Pittsburg, Penn., manufacturer of the "We-Fu-Go" and Scaife water-softening, purifying and filtering systems, has found it necessary to build an addition to the present plant at Oakmont, Penn., to accommodate the increased business in the building of systems for the purification of water for steam boilers, industrial and domestic uses, and is about to begin the erection of a shop 40 feet wide by 200 feet long, equipped with the latest improved machinery, which will be used in addition to the present shops for manufacturing the "We-Fu-Go" and Scaife systems. They have under construction at the present time for steam-boiler plants systems aggregating 95,000-horsepower, in addition to plants for softening and clarifying water to be used in manufacturing processes, such as dyeing and bleaching in woolen and cotton mills, and for washing in laundries; also a number of mechanical gravity filter systems for manufacturing and domestic use.

A shipment of unusual note was recently made to the Isthmian Canal Commission, Colon, Isthmus of Panama, consisting of seven 2½ kilowatt generator sets, built to meet the requirements of the I. C. C. Circular No. 472, Class 3, which called for them to be "built for high speed, self-oiling and automatically governed, and to be able to control, and also strong enough to withstand a change from no load to full load, to be of sufficient capacity to drive the 2½-kilowatt dynamo at the proper speed when under full load and with initial pressure of 60 pounds per square inch," etc. The Fort Wayne Electric Works, of Fort Wayne, Ind., which was awarded the contract furnished and shipped to the American Blower Company's Detroit plant, seven Type M. L. Frame D, 110-volt generators for mounting upon the extended subbases of seven 3¼x3 ABC vertical inclosed self-oiling Type A engines. The combined sets were tested and inspected by a Government inspector and readily approved.

New Equipment

City of Newton, Ala., voted to issue $8000 bonds for water works.

T. H. Marsden, Brady, Tex., will establish an ice plant and cotton gin.

The Torrington (Conn.) Electric Light Company will enlarge its power house.

The Board of Trade, Spencer, N. C., is considering erection of electric-light and power plant.

The Union (Ia.) Electric Light Company contemplates the construction of an electric plant.

Plans have been completed for the construc- of the municipal electric-light plant at Bergen, N. J.

W. A. Potter, Mizpah, Minn., has been granted franchise to construct and operate an electric-light plant.

The Bluestone Traction Company, Bluefield, W. Va., will install additional equipment in power plant.

The city of Brewton, Ala., contemplates the installation of engine and dynamo in the light and water plant.

The city of Franklin, N. C., will vote on issuance of $30,000 bonds for water works and other improvements.

The output of the municipal electric-light plant at Anderson, Ind., is to be increased. About $20,000 will be expended.

The Tryon (N. C.) Hosiery Company contemplates enlarging mill and will need new equipment, including boilers, engines, etc.

The Rockford (Tenn.) Cotton Mills, whose electric plant was recently destroyed by fire, is making arrangements to rebuild same,

The Hobart (Okla.) Water Power Company recently incorporated, is said to be planning to construct a hydroelectric plant. C. T. Blake is president.

Plans for installing a motor for pumping water in the municipal electric-light and water plant at Rockport, Mo., are under consideration. W. E. German is manager.

Plans are being prepared for a new factory for L. Adler Bros. Company, Rochester, N. Y. Equipment of plant will include four boilers, automatic engines, generators, motors, blowers, etc.

The Alabama Railway and Power Company is planning to start work on the proposed electric railway between Birmingham and Chattanooga. J. H. Hill, Fort Payne, Ala., is vice-president.

It is reported that the New York Edison Company will soon commence the construction of a central power station in the upper part of the city. Plant will have an output of about 20,000 horsepower.

Bids will be received until March 1 for the construction of a municipal electric-power plant in Lethridge, Alb., Can. George W. Robinson is secretary and treasurer. Smith, Kerry & Chace, Toronto, consulting engineers.

The Williamson Cold Storage Company, Williamson, N. Y., has been incorporated with $75,000 capital to conduct a cold storage, refrigeration and ice-making business. Incorporators, W. B. Freer, W. P. Rogers, K. M. Davies.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—Man familiar with laying out and selling power transmission machinery. State age, experience, reference and salary expected. P. O. Box 2062, New York City.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION WANTED as chief engineer, experienced with all kinds of engines, steam turbines, a.c. and d.c. generators, motors and switchboards, boilers and pumps. I can get results and furnish the references; have been seventeen years in the mechanical and engineering business. Box 9, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

Plant in Public Service Building, Milwaukee

A Large Noncondensing Turbine Plant Operating against 22 Pounds Absolute Back Pressure to Furnish Exhaust Steam for District Heating

BY OSBORN MONNETT

It is not often that a noncondensing turbo-generator plant of 4500 kilowatts capacity is designed to operate against a back pressure of seven pounds gage, or 22 pounds absolute. There is such a plant in operation in Milwaukee, and aside from the unusual fact that it is a simple noncondensing plant, there are operating features and conditions under which it was installed which make it of more than ordinary interest. Whenever possible, it is customary to locate a plant where the operating conditions will be most favorable; nevertheless, the engineer must, when necessity arises, be ready to design an installation and operate it when conditions are just the reverse. In the plant under consideration it would hardly have been possible to impose a more formidable array of adverse conditions, and the solution of the various problems are especially interesting from an engineering standpoint.

The plant was installed by the Milwaukee Electric Railway and Light Company and occupies the basement of the Public Service building in the heart of the business district of the city. This building is used as a terminal and waiting room for the various interurban street railway systems and for the general offices of the company. After the building was nearly completed the company undertook a contract to furnish exhaust steam to the Milwaukee Central Heating Company for its American district steam-heating system, and it became necessary to arrange for a plentiful supply of exhaust steam. It was not desired to rely entirely upon either the Oneida or Commerce street stations to supply the central heating system, and in any case it would have been necessary to install additional noncondensing equipment in these stations or to limit the capacity by operating some of the condensing apparatus noncondensing. So the extra generating capacity, instead of being divided up between the existing stations, was concentrated in an independent plant, the peak electrical load of which would come on simultaneously with the peak heating load.

Ordinarily it would not appear advisable to tie up such a heavy investment in noncondensing machinery, which would of necessity be idle for several months in the year, and which could be relied on in emergency during this idle period only at a great sacrifice of economy. However, in every lighting system there is a considerable part of the generating capacity which stands idle most of the year, but which is necessary to meet the peak load of short duration in the winter. This station, therefore, represents the excess or peak load generating capacity for the city lighting system, installed where the exhaust can be used to the best advantage; and with these considerations in

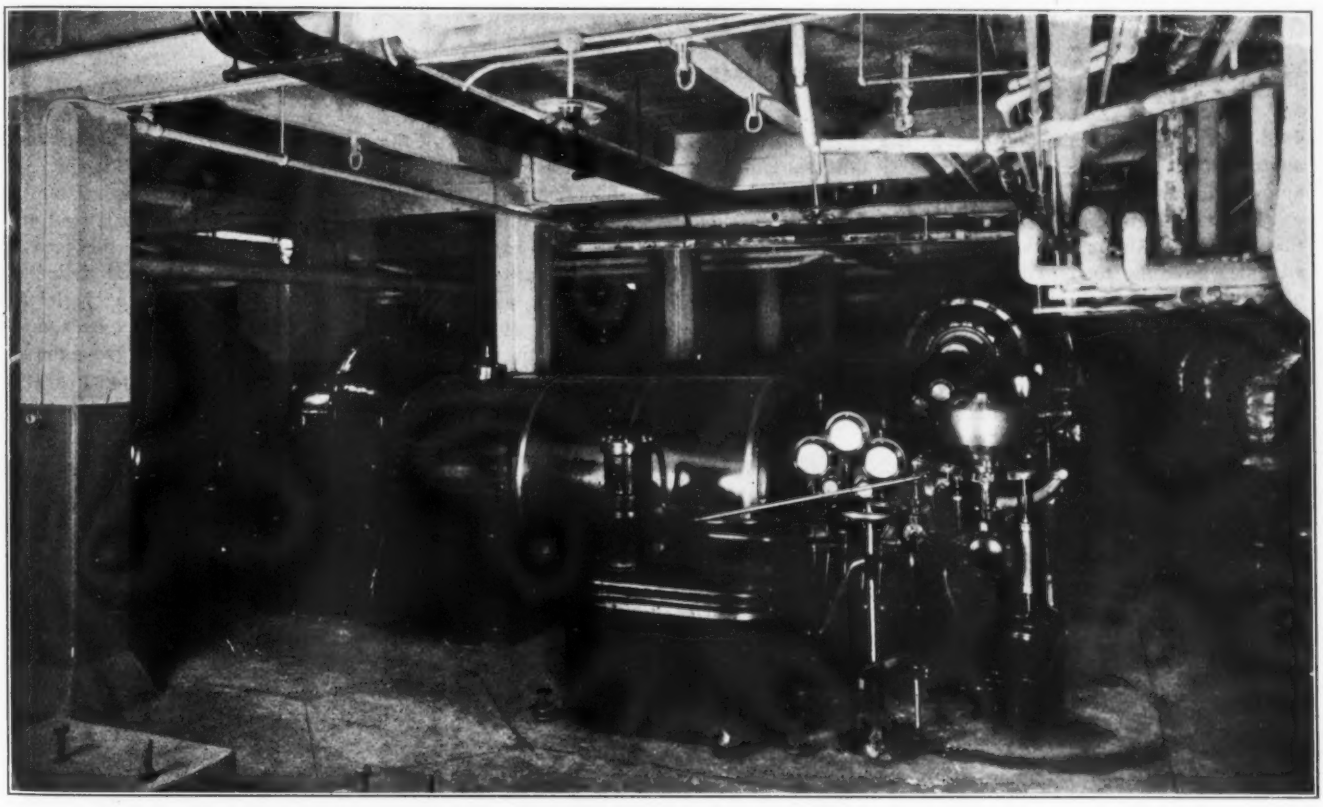


FIG. 1. THE TURBINE ROOM, MILWAUKEE PUBLIC SERVICE BUILDING

mind it can be seen that the existence of the plant is justified.

As the building was about completed before commencing to install any of the equipment, the machinery had to be lowered into the basement at the rear, literally through "a hole in the sidewalk," conveyed a distance of some 200 feet and erected under limited head room without cranes or other conveniences. The installation is a simple, noncondensing steam plant consisting of boilers, heaters,

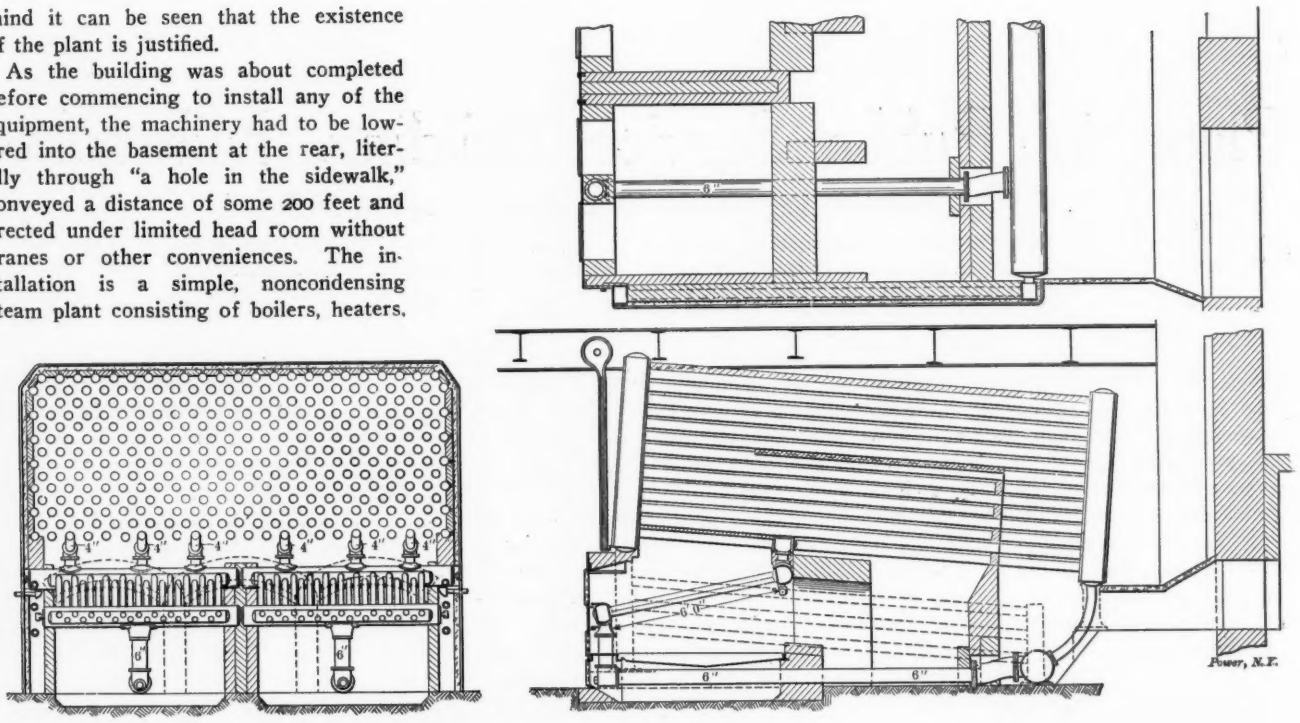


FIG. 2. ARRANGEMENT OF BOILER SETTING

feed pumps, generating units and the switchboard. Absence of the usual amount of auxiliary machinery in a plant of this size is marked, what there is of this pertaining more to the building as an office building than to the generating plant.

Steam Generating Equipment

For generating steam there are installed ten Edge Moor water-tube boilers of the drumless type, each rated at 400 horsepower on a basis of 10 square feet of heating surface per horsepower when neglecting 1500 square feet of superheating surface in the tubes above the water line. They occupy the southern side of the basement, as shown in Fig. 4, so that the space under the sidewalk becomes convenient for the storage of coal, a capacity of approximately 2000 tons being available. Youghiogheny screenings, which is the fuel used, are brought to the plant by wagons, dumped into the storage bin and fed to the furnaces by hand, and a motor-driven ash hoist elevates the ashes to the street level and loads them into wagons.

The columns of the building are supported on pedestals which spread out over a considerable area below datum and rest on piles, and owing to the slope of the foundations only a limited amount of excavating was permissible, this being done at the expense of the floor space. For this reason a head room of only 11 feet 10 inches could be obtained between the boiler-room floor and the I-beams of the ceiling. By arranging the highest points of the boilers to come between the I-beams, as shown in the elevation, the equipment was installed.

With the exception of having no steam drums, the boilers are of the standard Edge Moor construction. The handhole plates are made up with lead gaskets below the water line and with asbestos gaskets above, as superheat of some 30 to 50 degrees is obtained in the upper tubes. The mud drums slope forward from the rear header to conform with the limited floor space and are fitted on each end with two 2-inch Chapman gate valves in series. Squires feed-water regulators are used, and there is a feed valve on each side of the boiler, the feed entering each end of the mud drum.

One of the features of the boiler setting is an arrangement whereby some of the heat ordinarily radiated from the side walls is saved. This arrangement consists of a water leg, extending downward

FIG. 3. VIEW IN BOILER ROOM

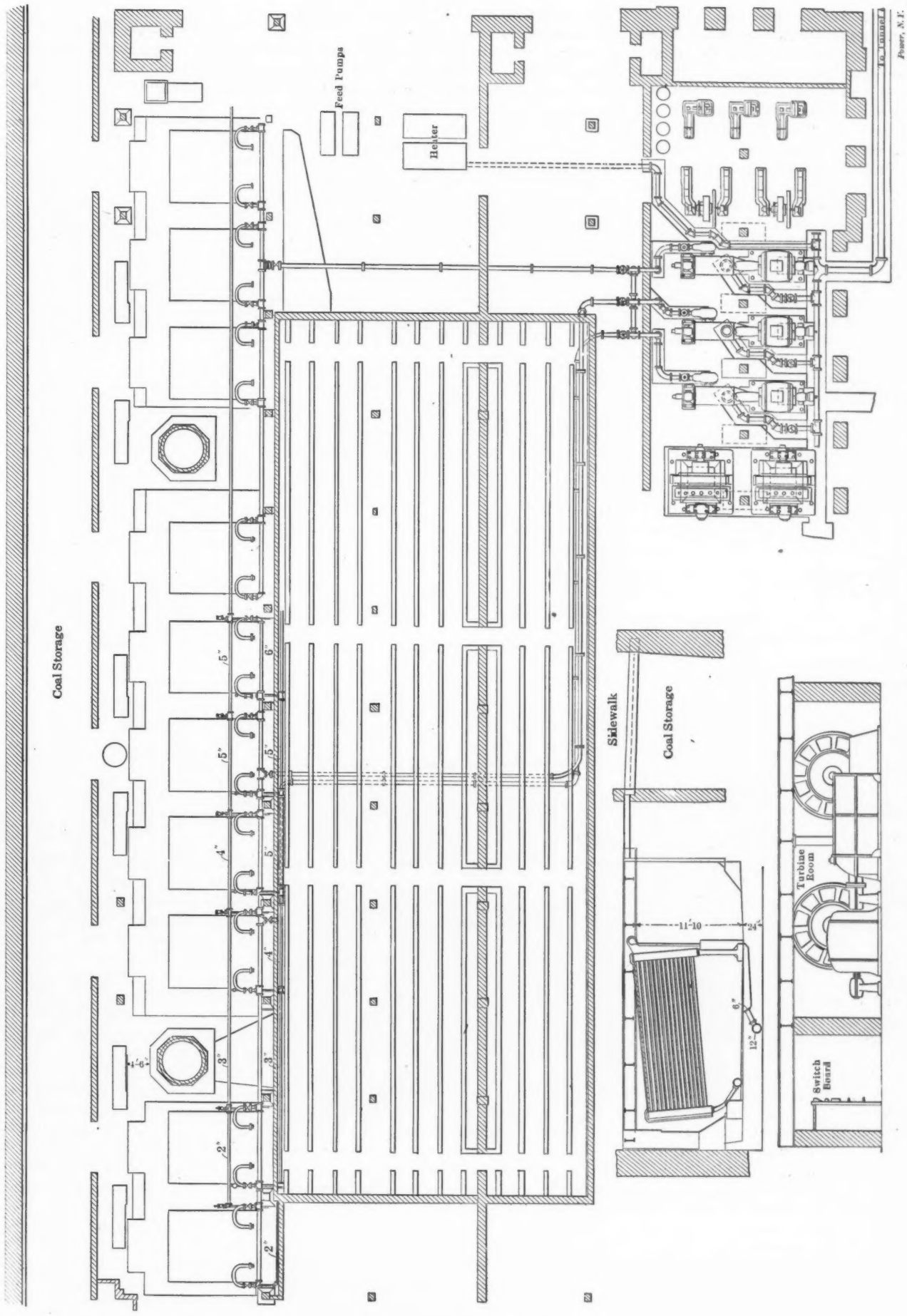


FIG. 4. PLAN OF POWER PLANT AND SECTIONAL ELEVATIONS OF BOILER AND TURBINE ROOMS

on each side of the front header, into which tubes are expanded and terminate in similar legs connected to the mud drum to allow free circulation of the water. The construction is indicated in Fig. 2.

Steam is taken from the top of the rear header on each side and passes to a 10-inch steam main immediately behind the boilers, through two 5-inch short-radius bends and Chapman stop valves. Hollow staybolts are provided in the front header for blowing the tubes. Fig. 3 shows a front view of the boilers. The piping is arranged so that the boilers are divided into three groups, each connected to its independent 10-inch header. These headers have no bypass connection with each other at the boilers, but the feeders to the turbine room are so tied together that any group of boilers may furnish steam for any turbine unit. Four boilers are connected to the first header and three to each of the two remaining headers. From the center of each header there extends a 10-inch line to the outside of the turbine-room wall, where the three lines are connected to a 10-inch manifold. By this arrangement any one of the steam lines may be cut out and steam supplied by the remaining two. Fig. 5 shows a plan and elevation of this arrangement. It will be seen that there is a drop leg under each steam line to collect condensation, if any should occur, and if desired the manifold may be cut out entirely and each unit be run on steam from its own battery of boilers. On passing through the turbine-room wall, the steam lines drop below the floor and at this level connect to the turbine throttles.

Owing to the restricted head room the boilers were necessarily made wide to get the required heating surface, and this construction permitted the installation of two Hawley down-draft furnaces. The upper manifold of each furnace is connected in three places to the lower tubes of the boiler. Circulation is then down from the rear header to the mud drum, thence through the horizontal central tubes to the lower manifolds at the front and up through the water-tube grates to the front header.

Feed water comes from the city mains to either of two 1500-horsepower Hoppes open feed-water heaters. It is fed to the boilers by two Worthington 14x8¼x 15-inch outside center-packed pot-valve pumps which are controlled by Mason regulating valves in conjunction with the feed-water regulating system. It was necessary to excavate to get sufficient head room for the pumps.

Two stacks, each 9 feet in diameter and 150 feet high, serve the boilers, five boilers to each stack, the gases being collected in rectangular flues and uptakes built of blast-furnace-slag cement.

Turbine Room

There are three Allis-Chalmers-Parsons type of noncondensing turbo-generators installed, each of 1500 kilowatts capacity, running at 1800 revolutions per minute and developing with star-connected generators 60-cycle three-phase current at 2300-4000 volts. To avoid vibration was the primary reason for installing turbines, but aside from that, it is extremely doubtful if the necessary engine capacity could have been put in place under the conditions of head room and floor space available. Even under the circumstances some ingenuity had to be exercised in making the exhaust connections, on account of the extended character of the pillar foundations. These were cut away sufficiently to allow the placing of a special rectangular casting connecting each turbine with the exhaust main.

Each unit has an oil-circulating system driven by worm gearing, by which the bearings are lubricated and which is also used to actuate the throttle valve under control of the governor. There is also installed an independent motor-driven oil pump to be used in starting and in emergencies.

The principal point in which the turbines differ from the standard condensing turbine is in length of rotor, a shorter machine being required for noncondensing service. The velocity of the steam is not enough to demand the low-pressure blades, which, if supplied in this case, would have had a velocity greater than could have been utilized by the steam under the excessive back pressure at which it goes to the exhaust. The machines were installed under a guarantee to develop a kilowatt-hour on 44 pounds of dry steam at half load, 40 pounds at full load and 41 pounds at 25 per cent. overload. It has been the practice to carry just sufficient load on the turbines to furnish the demand for steam on the heating system, and up to the present time there has not been enough demand to carry an economical load for long periods.

The accompanying boiler test, taken under ordinary working conditions, shows that, with an economical load on the turbines, a kilowatt-hour can be delivered at the switchboard for 4.23 pounds of coal, and this figure, it must be remembered, is obtained while operating against 22 pounds absolute back pressure.

The turbines exhaust into a 24-inch main which leads to the tunnel of the Central Heating Company. On this main is a 24-inch Crane relief valve with risers extending to the roof. There was no room which would permit of a 24-inch outlet

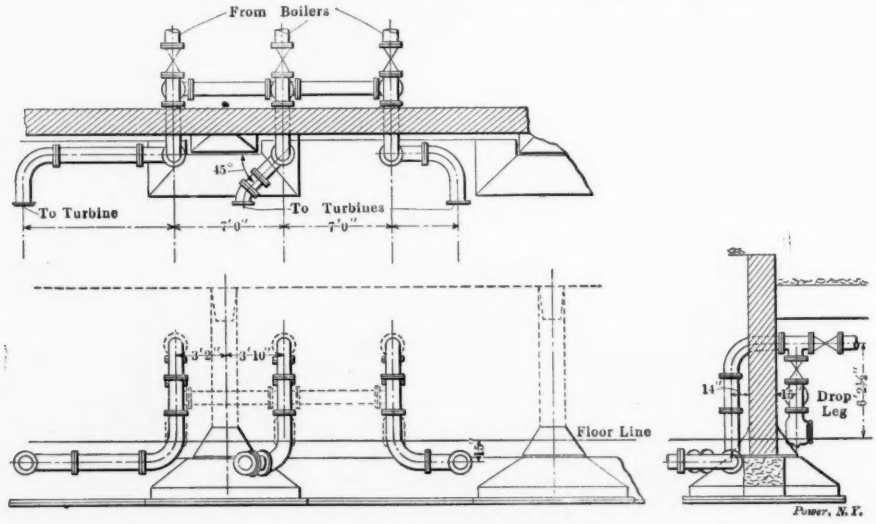


FIG. 5. STEAM HEADER MANIFOLD BETWEEN BOILERS AND TURBINES

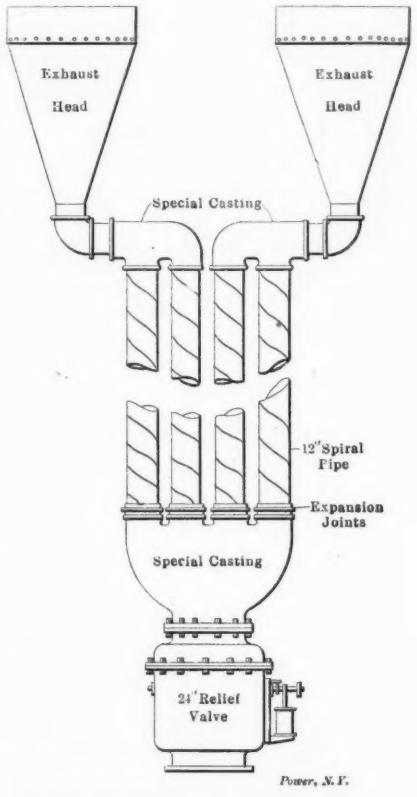


FIG. 6. DETAIL OF EXHAUST RISER

TEST OF ONE OF THE EDGE MOOR BOILERS.

Duration of test, hours	9
Heating surface, square feet (including Hawley furnace)	3,930
Superheating surface, square feet	1,504
Grate surface, square feet	2 Hawley furnaces 6′x6′x6″ each
Barometric pressure	29.3
Steam pressure absolute	162.9
Temperature of steam, degrees Fahrenheit	415.4
Chimney draft in inches of water	0.6
Temperature of feed water, degrees Fahrenheit	180.3
Temperature of escaping gas, degrees Fahrenheit	480
Pounds of coal burned as fired	13,600
Pounds of coal burned dry	13,042
Pounds of refuse	1,970
Pounds of combustible	11,072
Per cent. of refuse to dry coal	15.1
Coal burned per hour dry, pounds	1,449
Total pounds of water evaporated (apparent)	116,638
Degrees of superheat	50.6
Factor of evaporation (including superheat)	1.101
Total water actually evaporated, f. and a., 212 degrees, pounds	128,418
Total water actually evaporated per pound coal f. and a., 212 degrees, as fired, pounds	9.44
Total water actually evaporated per pound coal (dry) f. and a., 212 degrees, pounds	9.84
Total water actually evaporated per pound combustible f. and a., 212 degrees, pounds	11.59
Rated horsepower	400
Horsepower developed during test	413
Kind fuel used	Yougheogheny Screenings
Total B.t.u. per pound of coal	13,000
Per cent. efficiency of boiler	73.1

Approximate analysis: Moisture, 4.1; volatile matter, 28.7; fixed carbon, 56.7; ash, 9.6; sulphur, 1.7.

being installed, and it was finally found necessary to utilize a narrow space in one of the elevator shafts. As shown in Fig. 6, a special casting was made fitting the relief valve and having four connections. Twelve-inch spiral pipe was run from these connections to the roof, and here by the use of more special castings, the pipes were run into two 16-inch Crane exhaust heads.

Electrical Installation

Practically all of the electrical output of the station is used on lighting service, either as 2300-volt three-phase current or on the Edison three-wire 220-volt system. Alternating- and direct-current busbars connect with the other two stations, and the plants operate in multiple both on the alternating-current and direct-current sides, using for the latter service two 1500-kilowatt Allis-Chalmers motor-generator sets and a storage battery of 320 chloride cells. Each motor-generator set consists of a 2250-horsepower 60-cycle three-phase synchronous motor driving a 1500-kilowatt direct-current generator at 300 revolutions per minute and delivering current at 220-250 volts. The outfits are started from the direct-current busbars.

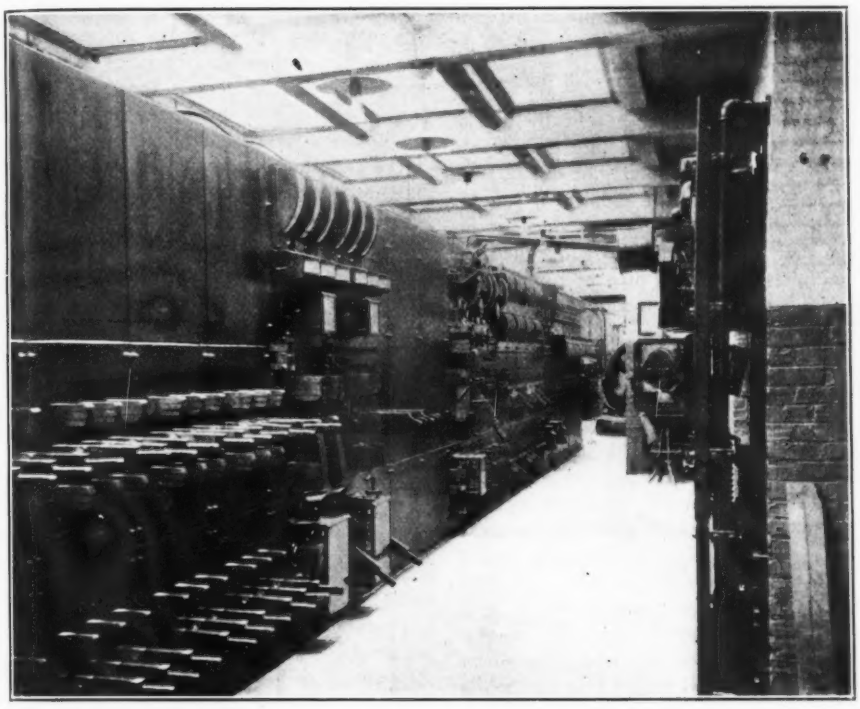


FIG. 7. SWITCHBOARDS

Each set has a generator panel carrying a Westinghouse edgewise ammeter, voltmeter, double-throw main switch, a Thomson recording wattmeter, alternating-current voltmeter, a direct-current field meter and power-factor indicator. There is a booster panel controlling a 150-kilowatt General Electric 1200-ampere booster for charging the storage battery. Two battery panels are provided with edgewise Weston ammeters, end-cell switch indicators and controlling apparatus. Twenty-four three-wire direct-current feeder panels, Fig. 7, are installed, with edgewise Weston ammeters on each wire of the three-wire system. There are no circuit breakers between the load and the direct-current side of the motor generators, but on the alternating-current side automatic circuit breakers are provided. Six lighting panels with a double set of busbars control the circuits in the building, each circuit having a double-throw switch so that it may be thrown on either the direct- or alternating-current side of the system.

The storage battery consists of 320 G-39 chloride cells of 1500 ampere-hours capacity, divided into two sets, having 20 end cells each. It is charged during the day and discharged on the peak load which comes between five and six in the evening.

Although ordinarily furnishing direct current, the motor generators tie the alternating-current and direct-current systems together in such a way that either side may assist the other in case of necessity, even to the extent of transforming the storage-battery supply into three-phase high-tension current.

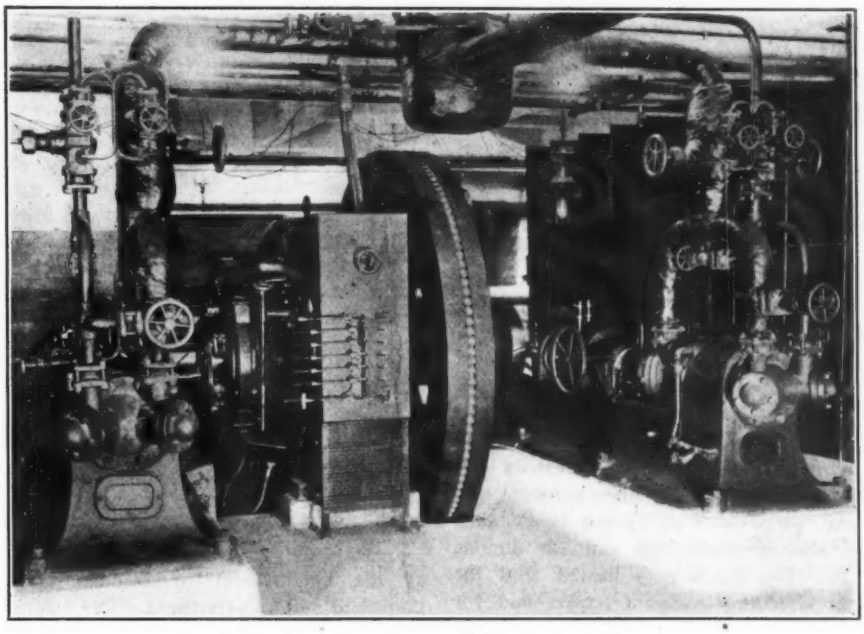


FIG. 8. MOTOR-DRIVEN REFRIGERATING MACHINE

Minor Apparatus

To cool drinking water in the building, a 25-ton Vilter refrigerating machine has been installed and is driven by a variable-speed Crocker-Wheeler motor, direct connected to the shaft. Waukesha water is brought in tank cars to the building and turned into two 10,000-gallon cement tanks in the basement. The expansion coils of the refrigerating machine are located in these tanks, and the exchange of heat is direct, without the intermission of a brine system. Two Yoeman motor-driven centrifugal house pumps circulate the water. The refrigerating equipment, shown in Fig. 8, is much larger than necessary for its present use, but it is the intention in the future to supply refrigeration to outside parties. Foundations are installed for a similar unit of the same size.

Other modern devices characteristic of a first-class office building are a vacuum cleaning system, the vacuum of which is obtained by a steam aspirator; and a Lamson pneumatic tube system for the transfer of papers, etc., from one department to another, this service being maintained with two 150-cubic foot Christensen motor-driven air compressors. A Stromberg auto-telephone system combined with the Bell system is installed for intercommunication and for outside calls. The building is heated with the Paul system of vacuum return, and for fire service there is provided a 6-inch single-stage Lawrence centrifugal pump driven by a General Electric 85-horsepower motor running at 750 revolutions per minute.

The plant as a whole is satisfactorily fulfilling the special purpose for which it was intended. It was designed and installed under the direction of C. J. Davidson, chief engineer of power plants.

The Use of Wooden Rings in Water Mains

By William Kavanagh

In laying large pipe intended for conveying water the employment of wooden rings, shaped to suit varying angles and inequalities between elbows, tees, etc., and also to act as lengthening pieces between fittings and flanges, will be found to be very important. In general, large pipe cannot be handled with the same facility as small pipe, it being practically impossible to force heavy pipe into line should fittings be tapped angularly or out of true, and in some cases the nipples or lengths of pipe will screw up farther into the fittings than anticipated, shortening the pipe. Sometimes lengths of pipe or nipples will be found bent, either through handling or because of some defect of construction, and when large pipe is to be connected and erected at a place remote from a shop having tools large enough to cut and thread it, the ingenuity of the pipefitter is taxed to remedy such troubles.

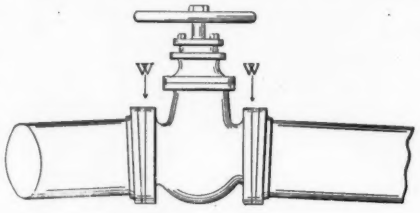


FIG. 1

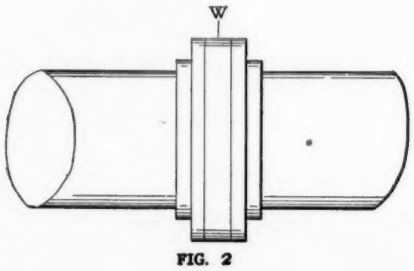


FIG. 2

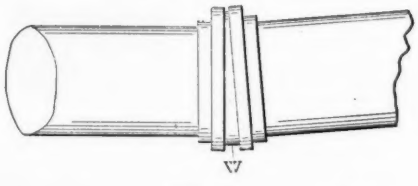


FIG. 3

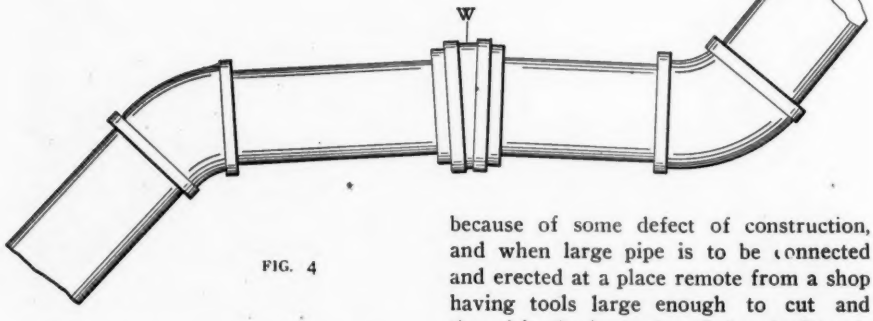


FIG. 4

Not long ago numerous difficulties were overcome, in the erection of a large water main intended for conveying water under a pressure of 150 pounds per square inch, by the employment of wooden rings shaped to suit requirements. The size of the pipe was 14-inch, and its installation through various winding passageways and crooked, narrow places called for the use of numerous short pieces of pipe, together with the usual flange unions, valves, tees and elbows. Whenever it was found expedient, a wooden ring was used. The ring was first shaped, then drilled and fitted to suit the bend or alinement of the fittings. After this, a rubber gasket was fitted to each side of the ring, or wedge, and the whole inserted in the desired position and bolted in place. Whenever the thickness of the wooden ring exceeded a certain amount, the length of the bolts had to be increased, and when the angle of the bend became acute the diameter of the bolts had to be decreased, in order to pass them through the holes.

Fig. 1 shows how the nipples approached the main stop valve and the application of the wedge-shaped wooden rings to fill out deficiency of alinement is shown at *W W*. Fig. 2 shows how a wooden ring *W* was employed to overcome deficiency of length. Here the nipples screwed into the fittings farther than was expected and the distance was made up by increasing the thickness of the ring, which in this case was 2 inches, a rather large amount to stretch a piece of 14-inch pipe. Fig. 3 shows how two nipples approached each other, having a flanged-union connection. It was found impossible to spring the nipples sufficiently to enable the bolting up of the union and at the same time have it face properly. The use of the ring *W* compensated for this deficiency.

Fig. 4 shows how the nipples and flanged union from two 45-degree elbows appeared when connected. The elbows and nipples lay close along a heavy stone floor, making it impossible to manœuver the elbows so as to have the union face properly. A wedged-shaped wooden ring, similar to that in Fig. 3, was employed, and it filled the requirements nicely. Fig. 5 illustrates the use of the wedge-shaped wooden ring between two 90-degree flanged elbows. Here it was found impossible to cant or swing the nipples so as to enable the correct facing of the elbows and permit of bolting them together. The use of the ring *W* was all that could be desired and it facilitated the connection of this part of the line more rapidly than if the heavy stone wall, over which the pipe had to run, were cut away.

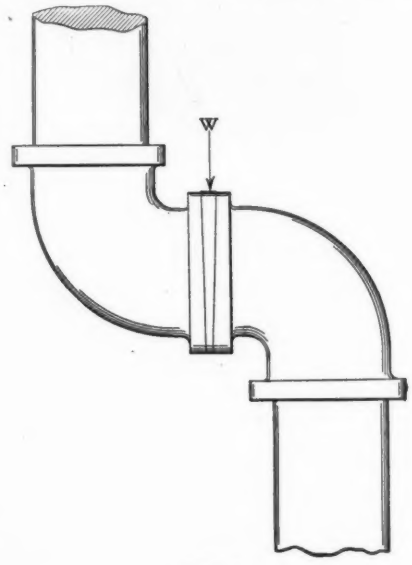


FIG. 5

In all cases the joints in which the wooden rings were used were water-tight and satisfactory in every respect.

A New Binding Agent for Coal Briquets

Consul George Eugene Eager, of Barmen, Germany, gives the following details regarding the advantages of briquet making by the use of sulphite pitch (selpech), with a preliminary statement concerning the making of coal briquets with tar pitch in general:

Only fifty years ago the dust of coal was considered to be entirely useless, but since then a great change has taken place and at present in Rhenish Westphalia the Ruhr coal district alone produces 3,000,000 tons of such briquets each year. The same increase is shown in the other European coal districts, i.e., Silesia, Belgium, England, etc.

Up to the present, coal-tar pitch (so-called brai) has been used for making coal briquets, and its production in the past ten years has increased about 100 per cent. Most of the coal-tar pitch is produced in England and Germany, the latter country only being able to produce for its own consumption, while England supplies the remaining consumers, i.e., America, Russia and Belgium. As stated, the coal-tar pitch production is limited, and consequently in the United States and Russia only comparatively few briquet manufactories are to be found.

The coal-tar pitch is an excellent binding agent for baking and coking coal, especially bituminous; it burns easily and gives the briquets hardness for long-distance transport, but various qualities of good briquet material cannot be bound with it, thus making its common availability impossible. Its numerous disadvantages are as follows: It produces very much smoke and has a very disagreeable odor; it cannot stand high temperature, and becomes soft and difficult of use in hot or extreme weather; the dust and fumes of coal tar, being corrosive, are very injurious to the skin, eyes and lungs of the workmen employed, causing diseases of those organs. The low temperature at which it ignites, although an advantage when used with soft bituminous coal, becomes a great disadvantage when the attempt is made to use materials that burn less easily. The coal tar becomes soft and burns much more rapidly than the coal flowing out of the briquet, leaving the coal to fall to pieces in dust and remaining unconsumed.

New Material from Wood Cellulose

For this reason it has been impossible to briquet anthracite, semi-anthracite, or coke gravel with coal-tar pitch, it being unable to resist the heat and pressure of the blast furnaces; therefore a binding agent which overcomes all of the difficulties mentioned ought to have the most brilliant prospects for the future.

This long-sought-for binding agent has been found in the "sulphite pitch." The material is obtained in the process of manufacturing sulphite cellulose. The wood is put through a washing process in lye by which the fiber is cleared of all resinous ingredients, it being pressed out from the wood pulp. Thus far this material has been entirely useless. Through a cooking process it is reduced to a highly glutinous substance called "sulphite pitch."

The sulphite pitch possesses many qualities which show its excellent advantages as a binding agent. It is intensely glutinous and possesses a high binding power. In the ordinary briquet of bituminous coal from 7 to 10 per cent. of coal tar is used to give it the proper hardness, and with the use of sulphite pitch the same results can be obtained by the use of 5 per cent. There are qualities of coal and ore that can easily be made into briquets with from 2 to 3 per cent. of the sulphite pitch.

Sulphite pitch burns without smoke or odor and is an ideal fuel for the household as well as for industrial purposes. In cities where the smoke nuisance has heretofore prevailed the use of briquets made with this sulphite pitch will form a solution of the smoke question. Trials have already been made with coke briquets made with this new process in blast furnaces and on torpedo boats, with the most sanguine results. The former tests not only showed a saving of 30 per cent. coal, but the iron showed almost an entire freedom from sulphur. In its trial on the torpedo boats it not only proved a perfect fuel, but the entire absence of smoke proved its advantage over other fuels in time of war. Ocean liners, warships, railway engines and factories could all use this fuel to advantage and not only economize in the amount of fuel necessary, but would relieve the cities from the smoke nuisance.

Availability of Materials

Sulphite pitch does not soften under heat and burns at a high temperature. It can be ground to any consistency or can be produced directly in any form of powder; it can be had in every country where there are cellulose mills, and it is very cheap, unlike the coal-tar pitch, which is rare and expensive. Many attempts have been made to briquet anthracite, liguite, coke gravel, or dross, even with a very high per cent. of coal tar, but without success. These disadvantages all disappear with the use of the sulphite pitch. Anthracite briquets for household use (egg form for American stoves) manufactured with sulphite pitch burn smokeless and scentless; therefore, they are not only an excellent substitute for the anthracite nuts, but are even superior to them.

Recent trials to briquet coke gravel and dross the remainder of coke (hitherto useless) with tar pitch have proved failures, but the situation changed immediately as soon as sulphite pitch was used as the binding agent, and the results show a briquet that can be considered a perfect substitute for coke. Practical trials of these briquets in both blast and cupola furnaces have shown that the briquets do not fall to pieces even under the highest temperatures, but burn while gradually shrinking. On account of their consistence they enter deeply into the melting zone of the furnace, thereby naturally contributing materially to the melting effect. Fine ore, bog iron ore, brown ore, mangan ore, oxide, furnace cadmia (iron dust from blast furnaces), and other ores can all be made into briquets by the use of sulphite pitch and successfully melted in the furnace. All trials of these materials with coal-tar pitch have failed, because the binding agent burned away at a lower temperature, leaving the material in dust as before. With sulphite pitch it is possible to briquet furnace cadmia so that it can be melted in a blast furnace. This alone means a great saving to the iron industry.

Constituent Elements—Process of Making

In general, sulphite pitch consists of the following substances: Coke, 25 to 35 per cent.; volatile matter, 50 to 60 per cent.; ashes, 8 to 12 per cent.; water, 10 to 15 per cent.

The latest chemical tests have proved that the percentage of ashes can be materially reduced. Through the origin of sulphite pitch its ashes contain sulphur up to 20 per cent., or 2.5 per cent. of the sulphite pitch. The sulphur, however, is tied up to iron and lime, which latter substances are always present in abundance, so that the sulphur remains in the ashes and cannot do any damage. It is true that sulphite pitch can be dissolved in water, and that briquets made from it are not waterproof; but this is of no great importance, as in most cases a waterproof briquet is not needed. The sulphite-pitch briquet is, however, more waterproof than the lignite briquet, the making of which has become a flourishing industry. The sulphite briquet is not hygroscopic, and can be made absolutely waterproof, if it is necessary, by a simple special treatment.

It is not supposed that sulphite pitch will in any way interfere with the coal-tar pitch in its use for soft bituminous coals, but the superiority of sulphite as a binding agent for the harder coals and cokes, also iron dust and other ores, opens up a new and very important industry. Already a large coke-briquet factory has been built in Lüttringhaus, near Barmen-Elberfeld, and the entire output of the factory was sold out at once. Another large factory is in course of construction in Aix la Chapelle.—*Consular and Trade Reports.*

Guide to Small Station Switchboard Design

General Instructions and Suggestions for Station Managers for Laying Out Switchboards for Small Alternating- and Direct-current Plants

It frequently happens that the switchboard equipment of a small station must be almost if not entirely superseded by a new switchboard in order to meet the requirements of increased load and unexpected changes in the character of the load. In many such cases, the work of laying out the new switchboard devolves upon the operating head of the plant because the owners consider it too small to justify the employment of a consulting engineer. To meet such cases, the General Electric Company has formulated general fundamental instructions and suggestions which will be found most helpful to station managers confronted with the conditions mentioned. Because of the highly useful character of this material we reprint herewith that portion of it which relates to alternating-current stations of 2300 volts and direct-current power plants of 575 and 275 volts.

2300-volt Alternating-current Switchboards

Exciter Panels

The exciter panels should preferably be arranged for the control of only one exciter from each panel for the reasons that the panel and the exciter can be considered as a unit, and can be disposed of together if any change is made in the equipment; a more symmetrical arrangement can be made of the instruments and other devices, and the switchboard can usually be laid out with a fewer number of sizes of panels.

The equipment recommended for exciter panels is as follows: One ammeter, one field rheostat handwheel, one single-pole, single-throw switch and one two-point potential receptacle. Negative and equalizer switches should be mounted on or near the machines. A fuse on a base behind the panel may be added, if desired.

The best plan, as a rule, is to use only one voltmeter for the exciters, and mount this on a bracket at the end of the switchboard. If a voltmeter is used for each exciter, it may be mounted on the corresponding exciter panel; a potential receptacle will then be unnecessary.

Generator Panel

The standard equipment of a three-phase generator panel is as follows: Three ammeters, one polyphase-indicating wattmeter, one voltmeter, one field-circuit ammeter, one single-pole single-throw field-circuit switch with discharge clip, one handwheel and chain mechanism for field rheostat, one four-point synchronizing receptacle, one eight-point potential receptacle and four-point plug, one triple-pole single-throw nonautomatic oil switch, two current transformers and two potential transformers.

A synchronism indicator is recommended in all cases. The best place for it is on a swinging bracket at the end of the board.

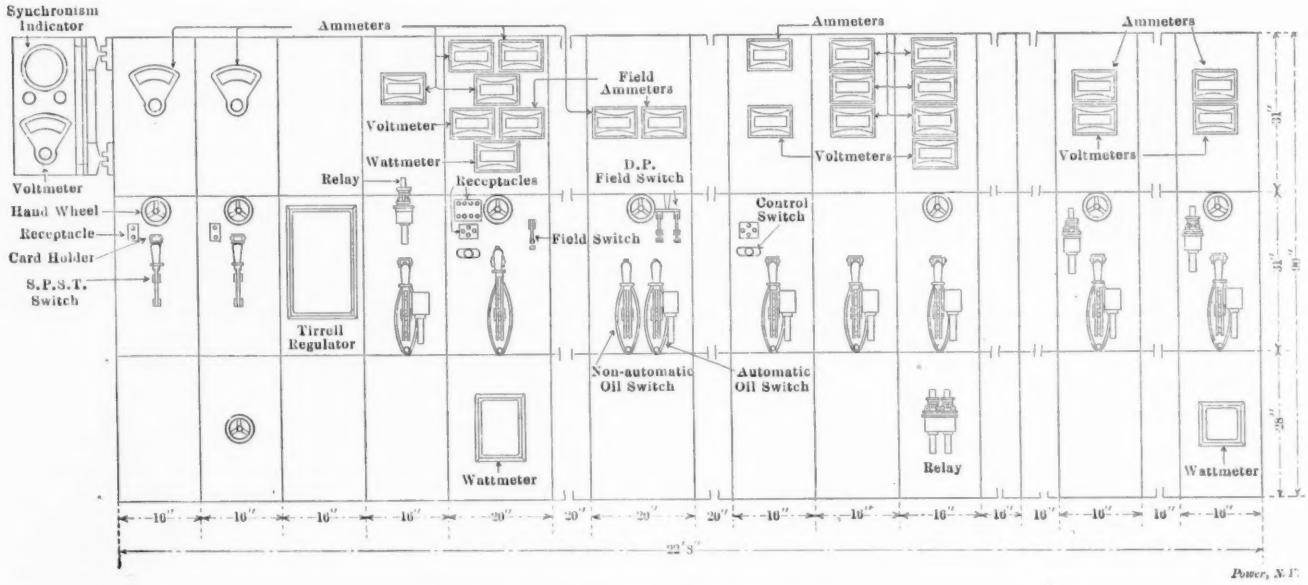


FIG. 1. FRONT VIEW OF 2300-VOLT SWITCHBOARD

Induction-motor Panels

When exciters are driven by induction motors, it is necessary to provide a panel for the control of the motor. The equipment should consist of one ammeter, one triple-pole single-throw automatic oil switch with bell-alarm switch, and one inverse time-limit overload relay. If a Tirrill regulator is installed, there will usually be room for it on this panel.

This arrangement is used also because the induction-motor panel is usually placed between the exciter panels and the generator panels. If for any reason the induction-motor panel is not so placed, it is better to use a separate panel for the regulator.

If the generators are rated in current output, as is customary with some builders, it is advisable to install ammeters on these panels in order that it will be possible to ascertain at any time exactly what current each machine is delivering. All three-phase systems are more or less unbalanced; therefore, in order to obtain correct readings, it is necessary to install an ammeter in each leg of each generator circuit.

Indicating wattmeters are important, as it is not possible to determine by any other means the division of load between two alternating-current generators running in multiple. The ammeters cannot differentiate between the idle component

and the work component of the current from a machine, and are therefore of no use in determining the division of load.

Field-circuit ammeters are useful, but not absolutely necessary. They serve as a check on the generator in case of trouble, and are valuable when testing for troubles.

Voltmeters are, of course, used to read the voltage of the machine before it is connected in multiple with any other. They are also used to indicate the potential of the busbars. The eight-point receptacle on the panel is provided to connect the voltmeter to any of the phases.

The field-circuit switch is equipped with a discharge clip, in order that the inductive discharge which occurs when the switch is opened can be dissipated through a resistance without injury to the machine or any of the other apparatus.

The synchronizing plug is used to connect the generator to the synchronizing busbars leading to the synchronism indicator. The General Electric Company has always recommended synchronizing between machines, and for this reason two types of plug are furnished with its switchboard equipment, one marked "Machine running," and the other "Machine starting." If a synchronism indicator is used, the proper connections will be made by means of these plugs, so that the synchronizing indicator will show whether the starting machine is operating too slow or too fast.

Usually the rheostat is too large to mount on the back of the panel. The handwheel can be mounted on the panel and connected to the dial switch on the rheostat by means of a sprocket wheel and chain or bevel gears, etc., or in some cases the dial switch of the rheostat can be placed on the panel and connected to the resistance by leads. The latter arrangement is objectionable, on account of the great number of leads and the expense. If rheostats are placed at any considerable distance from the switchboard, it is better to operate them electrically and mount simply the control switch on the panel.

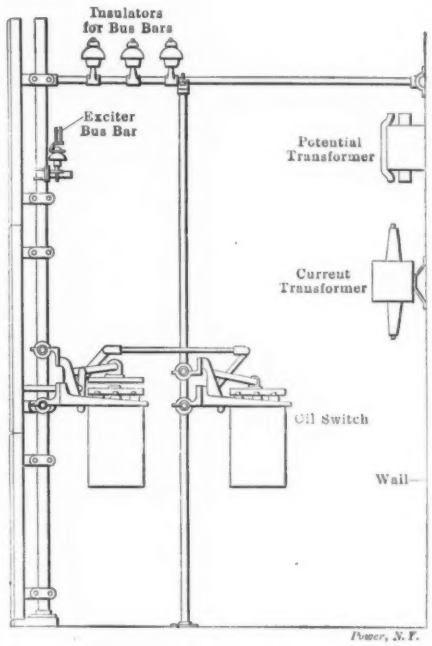


FIG. 2. SECTION THROUGH SYNCHRONOUS-MOTOR PANEL

Many engine builders furnish motors to adjust the governors of their engines, and it should be ascertained in each case whether such a device is to be furnished, and the type of motor used, in order that the proper switch can be mounted on the panel.

No automatic protection is recommended for alternating-current generators for several reasons. If automatic switches are used, there is great danger of shutting down the plant at the time of putting machines in parallel if the machines are not exactly in synchronism when they are connected together. If a short-circuit of overload occurs on any feeder, the generator switches are liable to open at the same time as the feeder switches, causing a shutdown. Most alternating-current generators are so designed that they are not injured by momentary short-circuits.

Synchronous-motor Panels

When motor-generator sets are used for furnishing either Edison three-wire direct-current service, or 500-volt railway or power service, the synchronous-motor panels should be equipped with one main ammeter, one field ammeter, one double-pole single-throw field switch with discharge clip, one rheostat handwheel and chain mechanism, one triple-pole double-throw automatic oil switch (automatic on one throw only) with bell-alarm switch, one triple-pole single-throw non-

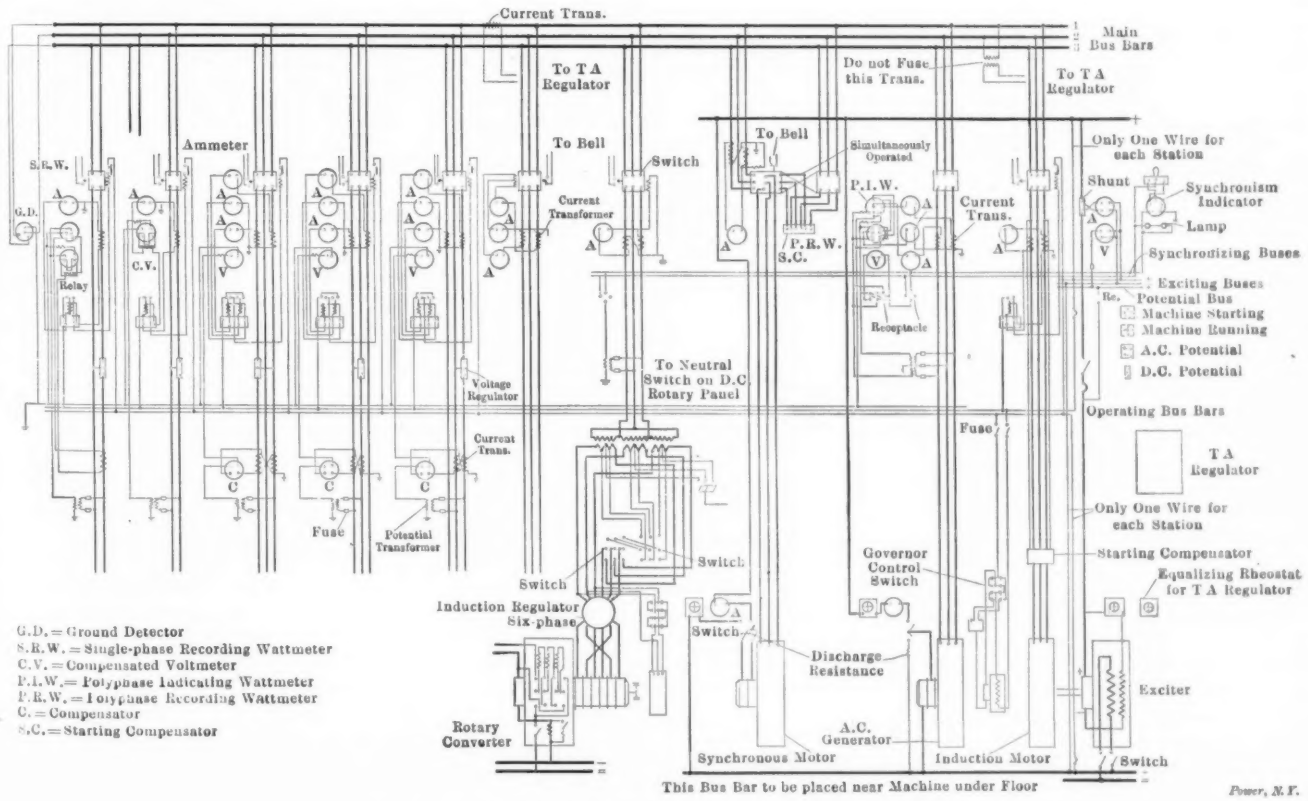


FIG. 3. DIAGRAM OF CONNECTIONS OF 2300-VOLT SWITCHBOARD

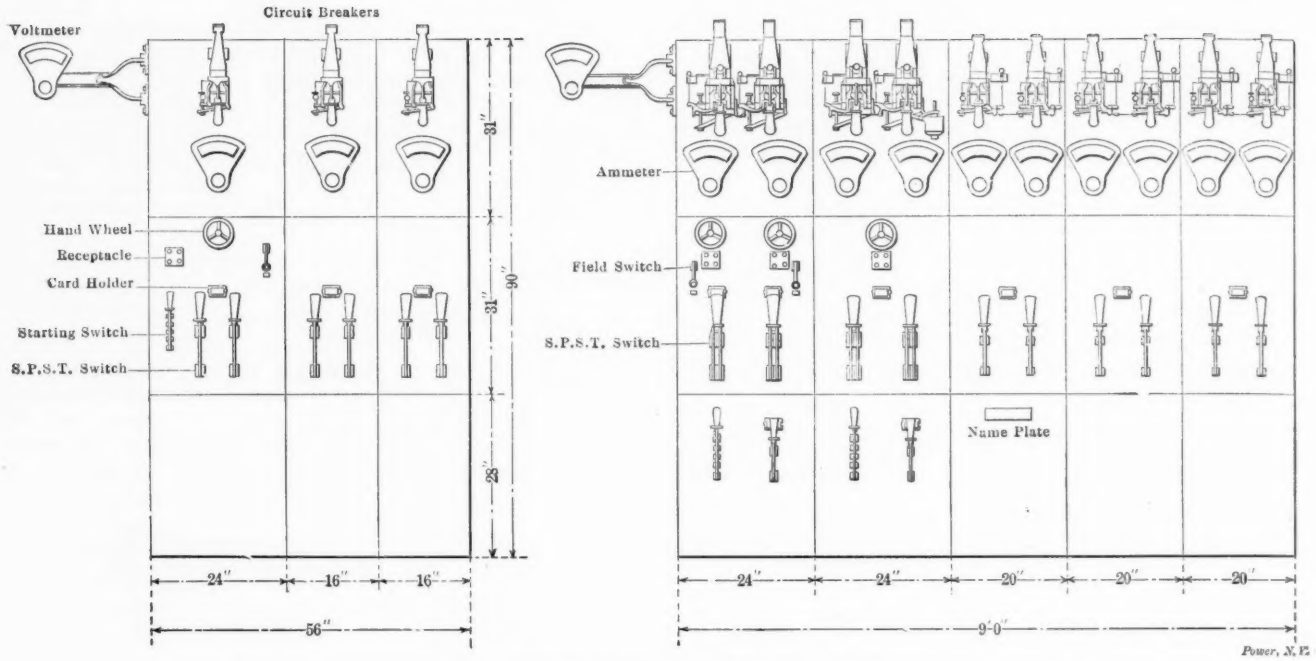


FIG. 4 FRONT VIEW OF DIRECT-CURRENT SWITCHBOARDS FIG. 5

automatic oil switch for compensator, and two current transformers.

If the synchronous motor sets are started only from the direct-current side, the main switch should be single-throw. If, however, they are started from the alternating-current side, the main switch should be made double-throw, in order that the motor can be connected to the starting taps on the compensator and then thrown over to the line by the switchboard operator.

When the sets are started from the direct-current side, it is necessary to synchronize and to add a voltmeter and potential transformer to the panel for reading the potential when synchronizing.

The arrangement of the field rheostats on these panels should be similar to the arrangement of the rheostats on the generator panels.

Rotary Converter Panels

Where rotary converters are used the alternating-current panel for the converter should have the following equipment, assuming direct-current starting: One main ammeter, one voltmeter, one synchronizing receptacle, one triple-pole single-throw automatic oil switch, with bell-alarm switch, two current transformers, and one potential transformer.

When rotary converters are used for furnishing Edison three-wire service, it is customary to install a regulator on the alternating-current side of the rotary, in order to be able to control the potential of the direct-current service. This regulator is usually motor-controlled, and in such cases a double-pole double-throw control switch should be mounted on the panel. The voltmeter is not necessary if no potential regulator is used.

Three-phase Feeder Panels

Three-phase feeders are frequently used for lighting, but are more generally used for power service. The equipment of each three-phase feeder panel should consist of three ammeters, one triple-pole single-throw automatic oil switch with bell-alarm switch and two current transformers.

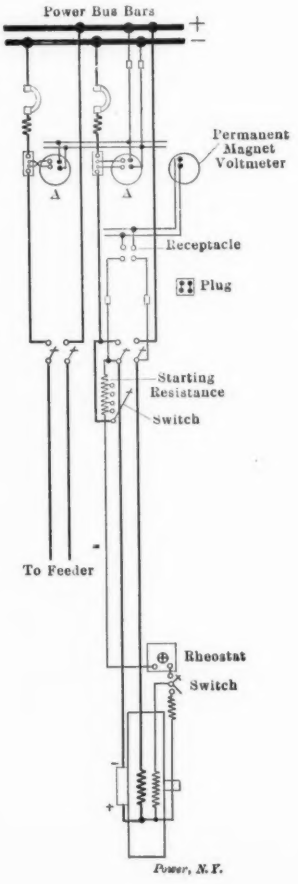


FIG. 6

If three-phase feeders are used to supply lamps as well as motors, the preferable method for operating the lighting circuits is to connect the lamps to one phase of the three-phase feeder and apply a regulator to this phase; this will afford complete control of the lighting. The usual equipment of a panel for controlling a circuit of this kind is as follows: Three ammeters, one voltmeter, one voltmeter compensator, one handwheel for the control of the regulator, one triple-pole single-throw automatic switch, with bell-alarm switch, four current transformers and one potential transformer.

If the regulator is located at a considerable distance from the switchboard, it is preferable to operate it electrically, and a double-pole double-throw control switch, instead of the handwheel, should be mounted on the panel. If the regulator can be placed close to the panel, however, it can be connected to the handwheel on the panel by means of either a sprocket wheel and chain, or by beveled gears.

Single-phase Feeder Panels

If single-phase feeders are used for lighting, the equipment should comprise one ammeter, one voltmeter of the compensating type, one double-pole single-throw automatic oil switch with bell-alarm switch, one current transformer and one potential transformer.

In case regulators are used, the same arrangement should be made on this panel for the control of them as is outlined for the three-phase panels.

Relays

The General Electric Company has de-

veloped what is known as the diaphragm-type relay, which operates on the inverse time element principle; that is, it can be adjusted to operate in a predetermined time with certain currents. If so adjusted, the time of operation is inversely proportional to the amount of current, and approaches an instantaneous value in case of a short-circuit. The use of this relay is recommended on all feeder circuits, alternating-current rotary converter panels and synchronous- or induction-motor panels, as it prevents the shutting down of the circuit by a momentary overload, yet will disconnect the circuit practically instantaneously in case of short-circuit or similar trouble.

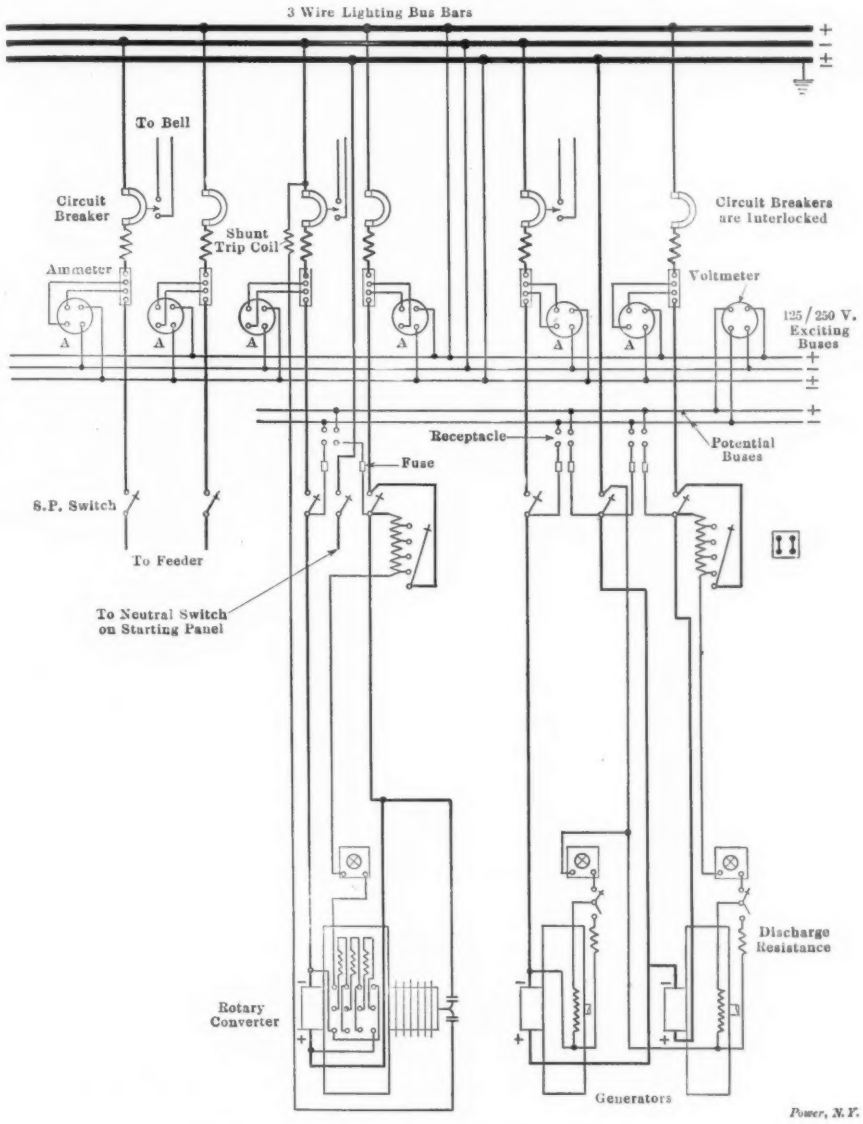


FIG. 7. DIAGRAM OF CONNECTIONS OF DIRECT-CURRENT SWITCHBOARDS

Ground Detectors

It is desirable to use an electrostatic ground detector connected to the busbars. This can be mounted on a stationary bracket at the top of the switchboard, or on a swinging bracket at the side of the switchboard. The bracket at the top is preferable, as it places the instrument beyond the reach of the station attendant and removes all high-tension apparatus from the switchboard proper.

Arrangement of Apparatus

There are many possible arrangements of the oil switches, current and potential transformers, busbars and connections. The best arrangement to employ depends on the design of the station and the proposed location of the switchboard. With the arrangement shown in Fig. 2 the busbars are mounted on a pipe framework at the top of the panel and the oil switches on the panel-pipe supports. The use of remote control switches makes a preferable arrangement, as the connections are then in such a position as to make the backs of the panels more accessible for testing, or for any changes or repairs which are found necessary.

Under no condition should the current and potential transformers be mounted on the back of the panel, because with such an arrangement the panel would be covered by the connections to and from the transformers, and thereby made inaccessible; in many cases the connections would be so crowded as to make the switchboard unsafe. The preferable location for these transformers is in the leads from the generators beneath the floor, if the leads come in from below, or on the wall in case they come from above. Transformers connected to the feeder circuits should be mounted on the wall if the feeders go out above, or beneath the floor if they go out underground.

Fig. 3 is a rear view of the switchboard in Fig. 1, showing the connections between the various instruments and operating devices.

Direct-current Switchboards

Fig. 4 shows a direct-current switchboard arranged for 575-volt power service. The panel shown at the left of the drawing is exactly the same whether used with a rotary converter or a generator driven by a motor or an engine, excepting that no field switch is needed for converter panels. The equipment of this panel should be one circuit-breaker, with bell-alarm switch, one ammeter, one handwheel and chain mechanism for the rheostat, one single-pole single-throw field switch with discharge clip, one four-point potential receptacle and two single-pole single-throw lever switches.

One voltmeter should be mounted on a swinging bracket placed in some convenient location.

If machines are equipped with speed-limit devices it is customary to provide low-voltage release or shunt trip coils on the circuit breakers.

If the generator is a part of a motor-generator set and is to be arranged for direct-current starting, a four-throw starting switch should be mounted on this panel. If the generator is driven by an alternating-current motor, the alternating-current panel already described should be used for the control of the motor.

Feeder Panels

The equipment of the feeder panels should consist of one single-pole circuit-breaker with bell-alarm switch, one ammeter and two single-pole single-throw feeder switches. If desired, one of these switches can be omitted, the remaining switch being connected in one side of the circuit and the circuit-breaker in the other.

275-Volt Three-wire Switchboard

Fig. 5 shows two direct-current machine panels; one is for the control of two low-voltage generators operated on the three-wire system, and the other is the direct-current panel for a rotary converter. The panel for controlling the two direct-current generators would be exactly

the same for motor-driven machines and should have the following equipment: Two circuit-breakers with interlock and bell-alarm switch, two ammeters, two handwheels for field rheostats, two single-pole single-throw field switches with discharge clips, two four-point potential receptacles for voltmeter plugs, three single-pole single-throw lever switches and one four-throw starting switch (for motor-driven generators). If the two generators are engine-driven, of course the starting switch can be omitted.

The direct-current rotary converter panel should have the following equipment:

Two circuit-breakers with interlock, shunt trip coil and bell-alarm switch; two ammeters, one handwheel for the field rheostat, one four-point potential receptacle for the voltmeter plug, three single-pole single-throw lever switches and one four-point starting switch.

It is generally preferable to start either a rotary converter or a motor-generator set from the direct-current side, as this causes much less disturbance of the system, which of course is important in lighting work.

The panels described are arranged for shunt-wound generators and converters as these machines are usually employed for lighting. If, however, compound-wound machines are used, equalizer busbars should be placed at a convenient point and the equalizer switches located either on the machines or on pedestals near the machines.

In the case of the two compound-wound machines supplying the three-wire system, it is necessary to have the series-field winding of the machine which operates on the positive side of the system connected in on the positive side of the machine. The machine operating on the negative side of the system should have its series-field winding connected in on the negative side of the machine; the circuit-breakers should be connected in the leads running to the neutral busbar. The reason for this is that the neutral is usually grounded, and as only one circuit-breaker is furnished for each machine, it is advisable to have this connected on the side of the machine which is grounded, in order to properly protect the machine against a ground in the leads from the machine to the switchboard, or on the machine itself.

A voltmeter should be mounted on a swinging bracket, as indicated in Fig. 5.

Feeder Panels

The feeder panels shown in Fig. 5 are each arranged for one three-wire grounded circuit. These panels should be equipped with two circuit-breakers with interlock and bell-alarm switch, two ammeters and two single-pole lever switches. There may be installed on one of these feeder panels a six-point receptacle, in order that the potential can be read between each leg of the system and the neutral when the rotary converter is running alone. There may also be installed a four-point receptacle for reading the potential across the outside of the three-wire service when only the generators are running. Figs. 6 and 7 show the proper connections for Figs. 4 and 5, respectively, as viewed from behind the switchboards.

Bridgewalls in Theory and Practice

By W. H. Wakeman

The chief engineer of a large manufacturing plant believed that the hot gases resulting from the partial combustion of coal could not be thoroughly consumed unless they were caused to pass through a narrow passage on their way to the chimney; therefore, when he installed two new 72-inch boilers he had the bridgewalls built in the form of an inverted

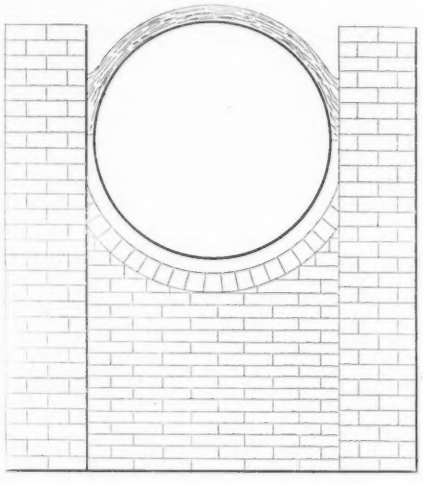


FIG. 1

arch, corresponding to the form of the shell, and the space between the top of this wall and the boiler shell was 3½ inches. See Fig. 1. Through this space all of the products of combustion passed on their way to the chimney and, according to the idea of this chief engineer, they became thoroughly mixed and burned during the process.

Fortunately the chimney of this plant created a very strong draft, otherwise the boilers would not have generated steam enough to supply the demand when a full load was on, as the following calculation shows: The internal diameter of a 3-inch tube is practically 2.8 inches, and the area is 6.157 square inches; therefore, the combined area of 120 tubes is 738 square inches, and it is safe to assume that the area of the passage for hot gases should not be less than this at any point between the boiler and the chimney. If the space above the bridgewall extends around one-half of the circumference of the shell, its area is

$$3.5 \times 108 = 378$$

square inches, or almost exactly one-half the area of the tubes; consequently, the draft is less than it would be if this space were twice as large, although the length of this contracted passage is short, which is a point in its favor. The temperature must be very high at this point, but the boilers were not damaged by it as long as they were kept clean.

There were 18 other boilers in this plant supplied with bridgewalls that were straight and level on top, with a space above them about 12 inches high at its lowest point. This chief engineer claimed that when these bridgewalls were clean thus making the full area of the passage effective, the efficiency of the boilers was reduced, because the hot gases were not completly consumed on their way to the chimney. His remedy for this evil was to allow soot and ashes to collect at this point, as shown in Fig. 2, and he would not allow this to be removed.

The real object in building a bridgewall

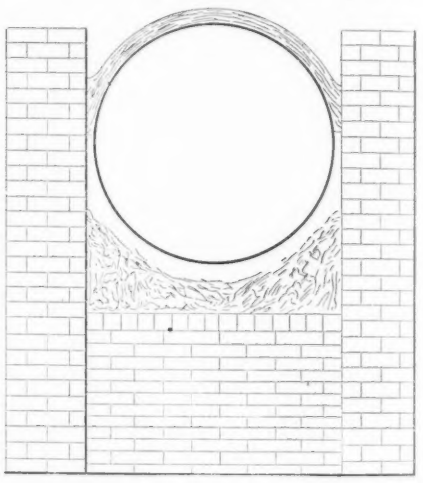


FIG. 2

is to hold the fuel in its proper place; therefore, it should be high enough for this purpose, and anything more is a waste of labor and material.

Bridgewall Too Low

The fronts of a pair of boilers that I had charge of for five years were designed so that the grates were about 20 inches below the shells. As Lehigh nut coal was burned in these furnaces at this time, a bridgewall 12 inches high above the grates was sufficient to hold the coal, even when the fires were banked; but, later, bituminous coal was adopted, and when this was shoved back to the bridgewall and the mass covered with fresh fuel to keep it from making steam during the night, the bridgewall was too low, as it was difficult to keep coal off it. To remedy this difficulty I had it raised 4 inches by setting firebrick on edge, as illustrated in Fig. 3.

This reduced the space from the bridge-

wall to the shell from 8 to 4 inches, but it did no harm. One of these boilers leaked badly at the girth seam near the bridgewall, and although the seam was chipped and calked several times in a workmanlike manner, it soon leaked again. Thirteen new rivets were put in and headed down while hot, thus causing them to hold more firmly when cold on account of shrinkage of the iron, but the leak was in evidence again within a few days. This would have proved conclusively to some engineers that the concentration of heat at this point was the cause of trouble; but this did not convince me, because I knew that the internal surface of the shells was practically clean at these points.

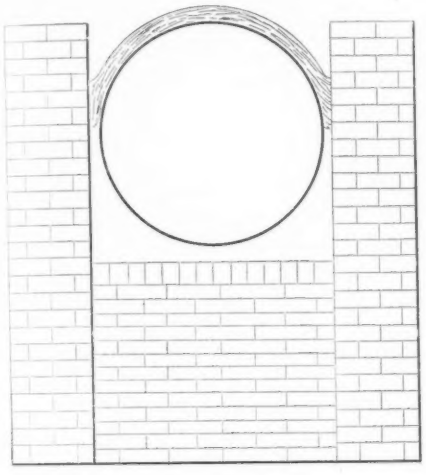


FIG. 3

Bridgewall Too High?

No objection was made to this high bridgewall by the boiler inspector as long as I remained in charge of the plant, but when visiting the place a few months after taking charge of another plant, I found the bridgewall cut down as illustrated in Fig. 4. It was reported that this was done by order of the boiler inspector, who objected to the high bridgewall because it resulted in the concentration of too much heat at this point.

Since then I have read the opinion of a careful writer on this subject, who points out in an earnest manner what is a fact to him beyond dispute, namely, that a bridgewall should never be cut down in this way, because nearly all of the hot gases will rush for this part of the passage and the result will be a ruined boiler. If either or both of these conclusions were correct, as illustrated in Figs. 3 and 4, it is certain that when a boiler is set as shown in Fig. 1, it would soon be rendered unsafe for use; yet, this is not true in everyday practice, hence my conclusion that a bridgewall is designed to hold the fuel in place and should be strictly so considered. If this part of a boiler shows signs of overheating, it is probably due to other causes.

Fig. 5 shows what was left of a certain bridgewall after wood had been burned in the furnace for several months. Heat is not concentrated at the point directly above this bridgewall, yet if the internal surface of the plate were covered with cylinder oil it would be overheated and rendered dangerous. The fuel burned in this furnace is not kept in place by the bridgewall (or anything else) and while this plan admits of burning long wood and thus saves the labor of cutting it into shorter pieces, there is nothing else to recommend it. On the other hand when an engineer allows his bridgewall to get into this condition and is satisfied to use it without improvement, he will probably be contented with dilapidated conditions elsewhere in the plant, to the detriment of first-class service. If this bridgewall should be properly maintained as shown in Fig. 3 and the wood cut into suitable lengths to enable the fireman to keep the grates nicely covered at all times, it would result in saving much fuel, and be more satisfactory on other accounts

Fig. 6 illustrates a squarely built bridgewall with ample space behind it for combustion to be completed. I know of no better plan, after thirty years' experience along this line, and I therefore continue to use it for coal, wood and shavings. The heavy dotted line represents the plan favored by some engineers, as they claim that when the sharp front corner is removed, the products of combustion pass over the bridgewall more readily, as the friction is less; but it is doubtful if this idea is correct, because I have never discovered evidence to prove that it is difficult for hot gases to climb over any kind of a square bridgewall, if the chimney supplied what is commonly called a good draft.

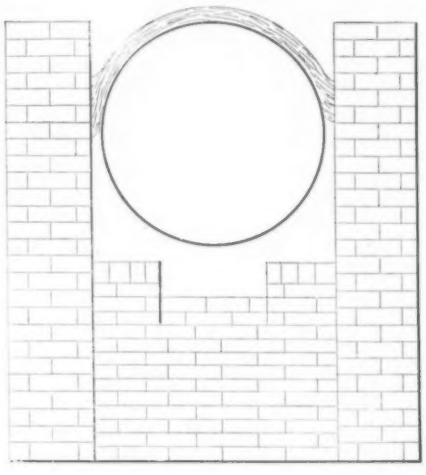


FIG. 4

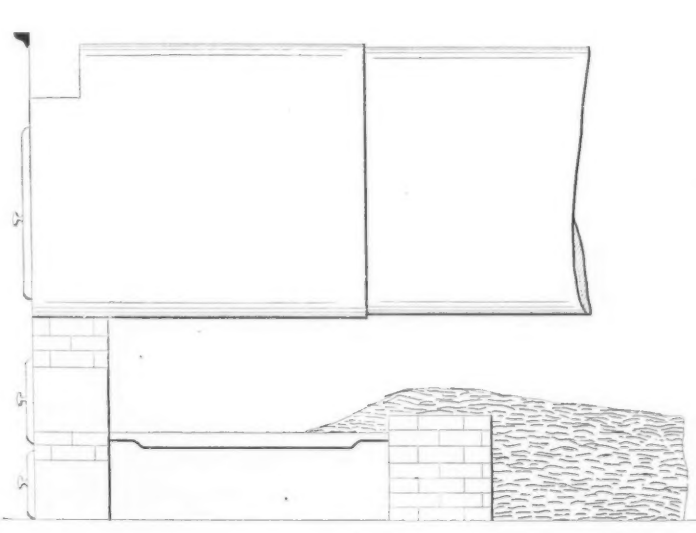


FIG. 5

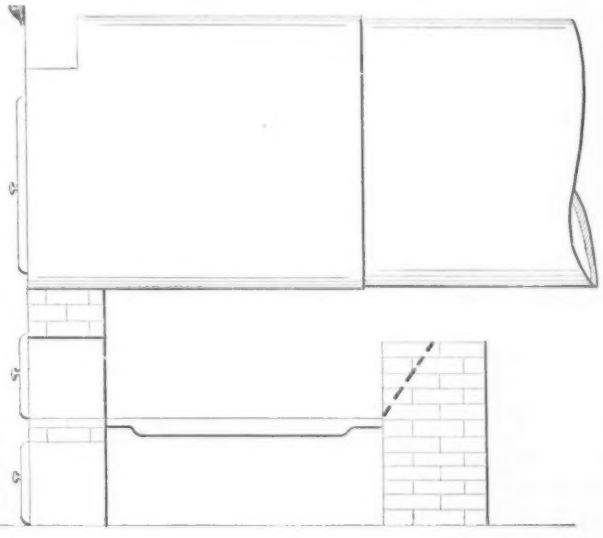


FIG. 6

These boilers were fed through the blowoff pipe with water that was heated nearly to the boiling point by a good exhaust-steam heater, but when this arrangement of piping was discarded and internal feed pipes installed the leaks disappeared and never returned. This experience shows that it is unsafe to decide on the cause of trouble of this kind without thorough investigation.

Draining High-Pressure Steam Lines

Why Water Should Collect in the Steam Piping, Its Effect on the System and Methods of Draining it Back to the Boilers or to Atmosphere

BY WILLIAM F. FISCHER

Probably the greatest source of danger to engines of the reciprocating type is the liability of water collecting in the steam-piping system, which unless stopped by a separator eventually finds its way into the engine cylinder in "doses" or "slugs" carried over with the steam flow. This is particularly dangerous in high-speed engines, owing to the small clearance space at each end of the cylinder.

Water Hammer

Pipes are usually proportioned so that the steam travels at the rate of about one mile a minute, or in some cases much faster, hence if a slug of water is picked up by the steam and carried along with it, an accident is apt to occur, either by the rupture of an elbow at a change in the direction of the flow, or by the water entering the engine cylinder. Although in some cases the quantity of water in the steam mains may not be sufficient to cause serious damage, it may, however, cause disagreeable knocking and hammering, which causes vibration, and in time causes the joints to leak. This knocking and hammering, so common in steam-heating plants, is what is known as "water hammer." Professor Thurston has experimentally shown that the pressure produced by water hammer may be as much as ten times, or more, that which the pipe, fittings and valves were originally expected to sustain in their regular work, and this fact is borne out in practice by the number of accidents traced to this cause alone.

Radiation and Pipe Covering

The presence of water in steam mains is due to the condensation of steam in the pipes, and in some cases to priming or foaming of the boilers, where water at times is carried over with the steam in large quantities. Heated surfaces naturally lose heat when brought into contact with a cooler surface or element, thus between two bodies near each other and at different temperatures there exists a tendency toward temperature equalization by radiation, conduction and convexion. A pipe carrying steam at a temperature of from 212 degrees and upward coming in direct contact with the surrounding atmosphere, the temperature of which seldom exceeds 100 degrees, is naturally a cause for rapid radiation of heat from the surface of the pipe to the atmosphere. This rapid radiation of heat causes condensation in the pipes, and is also a direct loss of the heat units derived from the fuel and stored up in the steam, and for this reason should be prevented as far as possible by covering all live-steam lines with a good nonconductive pipe covering.

Condensation and Superheat

Condensation may be divided into two parts: "static" condensation, which occurs when steam fills the pipe, but is not flowing through it, and "dynamic" condensation, which takes place when a valve is opened permitting the steam to flow. It has been found to all practical purposes that the amounts of condensation are almost equal in both cases.

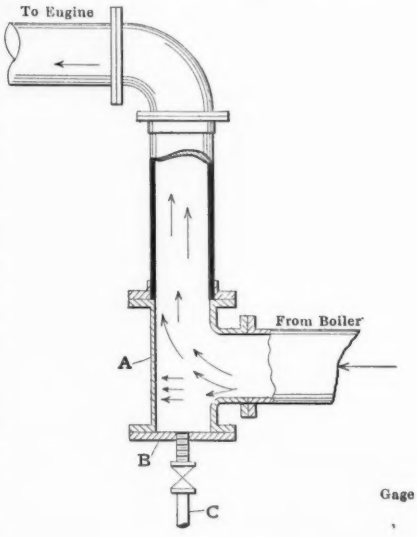


FIG. 1. A CONSTRUCTION OFTEN USED

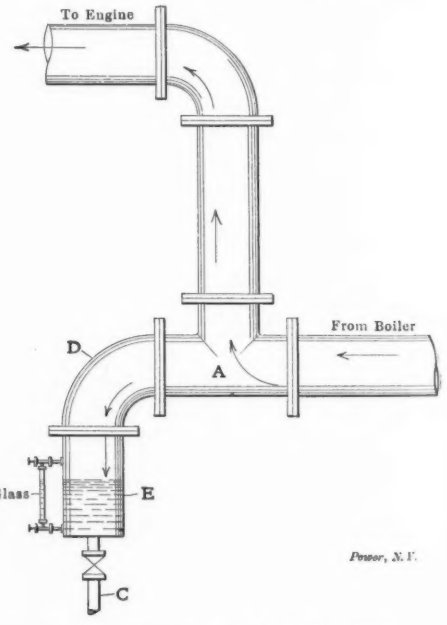


FIG. 2. A BETTER ARRANGEMENT

In modern plants with the use of superheated steam and the proper pipe covering, the condensation losses are reduced to a minimum as long as there is a rapid transference of steam from the boilers to the engines, but there are nearly always certain lengths of idle pipe in the system in which there is no flow; here the steam is bound to condense while the pipes are kept alive, and if they are shut off, there is danger of water forming in them when they are again opened to the steam. Before any water of condensation can form with superheated steam, the surplus heat units or superheat must first be extracted from the steam, or, in other words, the superheated steam must first be reduced to saturated steam at the same pressure, or less, before any condensation occurs.

Initial Condensation

Water has a large capacity for absorbing heat, and when allowed to accumulate in the steam mains has a tendency to condense part of the steam flowing therein. Any steam thus condensed, though perhaps in small amount, must be replaced by the boiler, and the extra steam generated for this purpose alone will amount to considerable money in fuel in a year's time. Initial condensation in an engine cylinder is a good example of this.

Water lying in the cylinder, or swept in by the steam, chills the cylinder walls, which in turn condense part of the steam entering at the next stroke of the piston. Consequently a greater amount of steam must be admitted to the cylinder than would otherwise be required to do the work. This initial condensation causes a corresponding drop in pressure at the engine throttle, and causes pounding and disagreeable knocking in the engine cylinder, as the water is slapped back and forth at each stroke of the piston.

Water in Steam Pipes and Its Effect

The presence of water in the steam mains also causes unequal straining in the piping and at the joints, as it tends to reduce the temperature of the lower side of the pipe as the water is swept along. Some boilers, when heavily fired or forced beyond their rated capacity, especially quick steamers and those having insufficient steam space, have an aggravating habit of throwing over large quantities of water into the steam header. This priming or foaming is also caused by impurities in the feed water, or is sometimes due to the presence of oil in the boilers. Then again, a sudden reduction of pressure in the steam main, such as is likely to occur when an extra engine is quickly cut into service, or to a sudden increase in the load, causes a corresponding reduction of pressure at the boilers, liberating the heat stored in the water. This heat flashes part of the water into steam, and in doing so, causes violent ebullition, and part of the water is entrained and carried over with the rapidly flowing steam to be deposited in the main steam header.

If this water is drained off as fast as it forms, no danger can possibly result from it, but if allowed to accumulate to any extent, the effective pipe area is gradually decreased to such an extent that when a heavy load is thrown on the station the resulting rush of steam toward the engines is bound to set the water in violent motion, projecting it with great force against a fitting or blind flange, and a rupture may result. Pockets or low spots in the piping where water can collect should be avoided, or if impossible to do away with them entirely, they should be dripped to insure keeping them free of water at all times.

Steam connections from the boilers frequently enter the main header at the bottom. This practice should be avoided as it leaves a pocket for the condensation from the header to drain into when either of the boilers is shut down. If it is attempted to run the water of condensation against the steam flow, water hammer is likely to occur, unless the pipe is exceptionally large and the velocity of the steam much below the average, as in heating plants, etc. The steam lines connecting the main steam header with the boilers, should enter the header at the top or on the side, and should drain toward the header. All steam lines to the engines should be taken from the top of the header where possible to do so, and should drain toward the engine separator.

Drip Pockets

Tapping a small pipe connection into the bottom of fittings on high-pressure steam mains for drainage purposes, is not to be commended as the steam flowing past a small opening sweeps the water over with it. Drip pockets of large cubical capacity should be used, having an opening or inlet equal in diameter to the steam main in which they are installed, on sizes up to 12 inches inclusive. For pipe above 12 inches in diameter, there is no advantage in increasing the size of the drip pocket, as the capacity of a 12-inch drip pocket is ample to handle all drips from the larger size pipe. These drip pockets provide an opening sufficiently large to catch the water before it is carried past them by the steam, and will also take care of any water carried over with the steam from the boilers, should they prime.

All drip pockets should be fitted with chain water gages operated from the floor so the valves can be quickly closed without danger of scalding the operator should the gage glass break. These gages show at a glance the hight of the water in the pocket at all times, also indicating whether the trap or drip return system is operating properly. In all cases it is a good plan to attach a drip pocket at each end of the main steam header, to keep up the circulation and relieve the header of condensation when either of the end boilers is shut down for cleaning or repairs. The greatest flow of steam is necessarily toward the largest outlet in the header, consequently the piping should be dripped through a drip pocket at this point, as water will be swept toward this outlet with the steam flow from each end.

Long lines of piping should be dripped at least every 125 to 150 feet. A tee and 3 or 4 feet of pipe, capped at the end with a blind flange drilled and tapped for a drip connection is a good substitute for a cast drip pocket, but should be fitted with a gage glass, as mentioned already. Drip lines under different pressures should never be run into one trap, but each should be trapped separately.

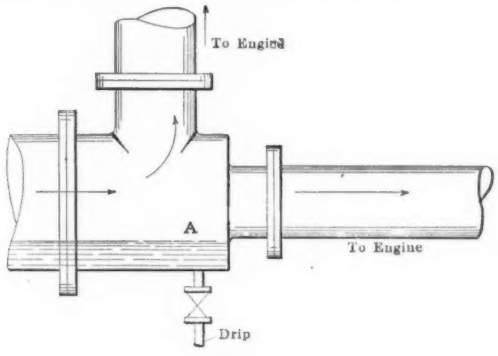


FIG. 3. REDUCING TEE

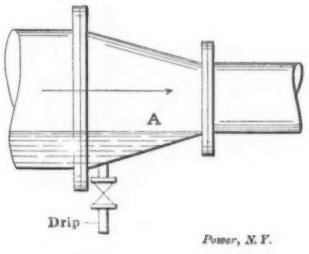


FIG. 4. REGULAR TYPE OF REDUCER

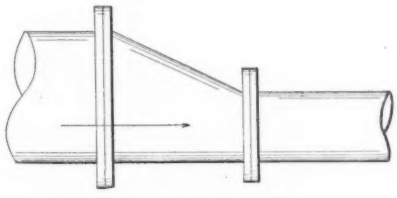


FIG. 5. ECCENTRIC REDUCER

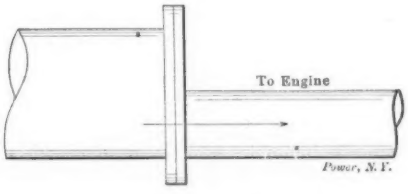


FIG. 6. ECCENTRIC FLANGE

Running Pump from Drip Header

A slow-moving pump for the purpose of boiler feeding, etc., will operate about as well on a mixture of steam and water as it will on dry steam, therefore the main steam line may be drained into a drip header run directly beneath it, and the steam connection to the pumps taken directly from the drip header. If the pumps are run continually while the main steam line is in service, they tend to keep

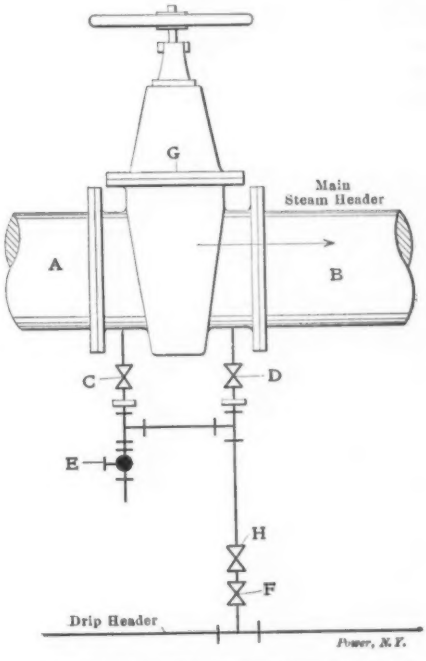


FIG. 7. DRAINING GATE VALVE IN MAIN STEAM HEADER

up circulation and keep the line free of water. If the pumps are shut down, however, there should be another means of removing the water of condensation automatically, either through a trap, gravity return system, steam loop, pump and receiver or other suitable means.

Water drained off through the steam cylinder of a pump should not be again returned to the boilers unless filtered to remove the oil it contains. This holds good for all exhaust-steam drips after passing through an engine or pump cylinder where oil is present. A swinging check valve should be installed in each drip connection between the steam main and drip header, to prevent steam or water from backing up in any section of the steam main while out of service. Since the amount of condensation to be handled by drip pipes is practically an unknown factor, no general rule can be given for proportioning them. The designer must use his own judgment in this, as well as many other matters relating to the design of the piping system.

Draining Water Pockets

Fig. 1 shows a construction very often used in draining the end of a steam line where steam is taken from the top of the header. The line rises through a tee *A* vertically, with one end capped by a blind flange *B* drilled for a drip connection *C*. With this arrangement of the piping, the water of condensation is swept along the header at high velocity by the steam flow, and upon striking the back of the tee is suddenly arrested and broken up into fine particles or drops, some of which are caught up again by the steam and carried up past the elbow and into the engine cylinder unless stopped by a separator.

Fig. 2 shows an arrangement of piping

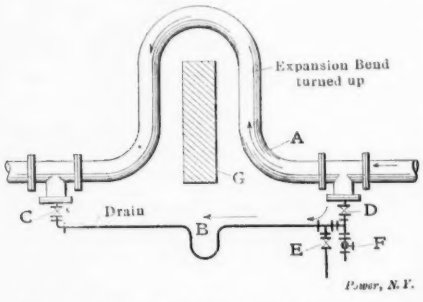


FIG. 9. DRAINING AN EXPANSION LOOP

much preferred to that shown in Fig. 1. The tee *A* is placed horizontally in the line, with the outlet looking up and a drip pocket *E* connected to the extreme end of the line through the elbow *D*. With this arrangement the water of condensation is swept along to the end of the line, falling through the elbow into the drip pocket *E*, where it is drained off through the drip line *C*.

In Fig. 3 is shown a section of a high-pressure steam line provided with a reducing tee. If the steam flow is in the direction of the arrows, a water pocket is formed in the line *A*. If the water which will collect here is not drained off as fast as it forms, a heavy flow of steam will sweep it over to the engine. Fig. 4 shows a line reduced on the run through a concentric reducer of the regular type. The results are the same as in the previous case. Figs. 5 and 6 show how this water pocket may be avoided by the use of an eccentric reducer, or an eccentric flange,

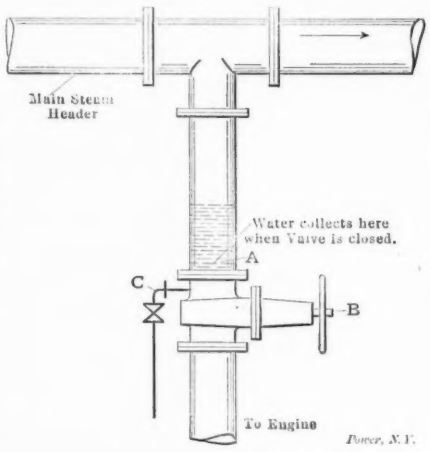


FIG. 8. WHEN STEAM IS TAKEN FROM BOTTOM OF HEADER

in place of the fittings shown in Figs. 3 and 4. The eccentric reducer is to be preferred to the flange in all cases, but the cost will be greater.

In cutting out a section of piping for repairs, or to renew gaskets, etc., workmen are sometimes scalded when breaking joints, due to some pressure still remaining in the line after the main valves are closed. When the bolts are loosened the water of condensation in the dead section gushes out, scalding the face or hands of the workman. The dead section should be well drained before opening the joints.

Fig. 7 shows a gate valve *G* placed in a steam main and dividing it up into sections *A* and *B*. This valve is dripped at each side of the gate or disk, through the drip valves *C*, *D* and *F*, and check valve *H* into the drip header. Globe valve *E* is for an open bleeder connection. If section *B* is shut down, the drip valve should be closed. The water of condensation forming in the live section *A* is drained off into the header through valves *C*, *H* and *F*, or if the steam were flowing in the opposite direction and section *A* cut out of service, drip valve *C* should be closed and section *B* drained through the valves *D*, *H* and *F* into the drip header.

With this arrangement of the drip piping and valves, the line may be used as a bypass around the main valve *G* to equalize the pressure in the dead section, or to warm it up gradually before opening the main valve, thus preventing knocking and pounding in the line due to water hammer. To use the piping as a bypass, valve *F* should be closed, and valves *C* and *D* opened to admit steam from one section to the other. When the main valve *G* is open and steam flowing, drip valves *C*, *D* and *F* should remain open to drain the line at this point.

When shutting down either section *A* or *B* for repairs, the dead section of the piping can be cleared of steam and water by opening the bleeder valve *E* and blowing out the pressure. For example, if section *A* were shut down, valves *D* and *F* should be closed, and drip valve *C* and bleeder valve *E* opened to the atmosphere, or *vice versa* with section *B* shut down. The check valve *H* is to prevent the water in the drip header from backing up into either section of the steam main when out of service, should the attendant forget to close the drip valves *C* and *D*. All the valves in the main line may be dripped in this manner satisfactorily.

When steam is taken from the bottom of a main, as shown in Fig. 8, the water of condensation collects at *A* when valve *B* is closed. The valve should be tapped above the seat for a drip connection at *C*. This drip line should be connected to a trap or into the drip header.

When installing an expansion loop or bend, it is sometimes impossible, for want of sufficient space, to place it horizontally as it should be, or, again, it is sometimes necessary to carry a steam line over an obstruction, as shown at *G*, Fig. 9. With

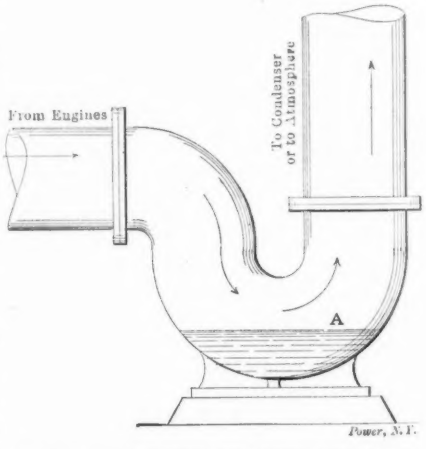


FIG. 10. CAST-IRON EXHAUST ENTRAINER

the bend turned up as shown, a water pocket is formed in the line at each end of the bend. A drip line should be placed as shown and bent at *B* to take up the expansion. The steam flowing in the direction of the arrows, travels up and over the expansion bend *A*, while the water travels along through the drip line below through valves *D* and *C*. A bleeder valve is provided at *F* and a connection to the main drip line or to a trap is made through the valve *E* in case it is required to drain the water off at this point. Valves

D and *C* should always remain open while the line is in service, to insure the water of condensation being carried on with the steam flow past the pocket at the inlet side of the bend at *A* in case the trap does not work properly or in case valve *E* is closed.

The drainage from any part of the steam-piping system is valuable on account of the water and the heat it contains, and should be returned to the boilers again by suitable means. Fuel is an important and expensive item of cost, and any means of saving fuel is a means of increasing the earning capacity of a plant, large or small. Sometimes the saving due to returning high-pressure drips to the boilers in small plants is not sufficient to warrant the expenditure for the necessary apparatus to do so. This is a point to be determined by the engineer familiar with the existing conditions.

Low-pressure Drips

Condensation from exhaust-steam lines always contains more or less oil, and for this reason should be filtered before returning to the boilers, as the presence of oil in the boilers causes burning of the plates and sagging. As a general rule this condensation is collected in a drip line and led off to the sewer, trench, condenser overflow tunnel or other convenient points, as in most cases it does not pay to attempt returning these drips to the boiler.

Fig. 10 shows an exhaust entrainer for removing the water of condensation from exhaust pipes in condensing systems. It consists simply of a double elbow which provides a pocket at the foot of the riser into which the drip water from the engines may drain, and is so arranged that the exhaust steam must pass over the surface of the water at *A*. The action of the exhaust steam is to entrain or pick up minute particles of water and carry them upward to the condenser whatever the hight of the latter. The particles are so infinitesimal that the loss of vacuum under any ordinary condition cannot be detected. These entrainers being provided with a substantial foot, serve as a support for the exhaust riser. They are chiefly used in connection with barometric condensers or condensers of a similar type.

Exhaust-steam mains under vacuum cannot be drained direct to the atmosphere while the condenser is in operation, as the minute a drip valve is opened, in place of the water flowing out, air rushes in and breaks the vacuum. There are several other methods, however, of draining exhaust-steam lines under vacuum, such as through a vacuum trap, the pump and receiver, etc., which it is not the writer's intention to discuss here.

Wet versus Dry Compression

By Joseph H. Hart

To the average operating engineer of the ammonia compression system, the terms wet and dry compression are merely relative and have no special significance. He knows that there are several methods of operating refrigerating machines in regard to temperatures, head and back pressures, and he has, as a general thing, his own little theory in regard to best conditions of operation. He also knows, in a general way, that various types of machine and various manufacturers are committed especially to the wet-compression, whereas others utilize the dry-compression type, and that in the wet-compression system the operation of compression is accomplished by carrying frost back on the suction pipe to the inlet valve of the compressor and in some cases completely covering the compressor with frost. The meaning of these two terms, however, and their significance from a scientific viewpoint, and the various factors which go to determine the relative efficiency of the two types, are matters practically unknown.

Now, in order to understand what is meant by these relative terms, it can be said in a general way that all ordinary compression is dry compression and yet the two terms are often used with a more general significance. Thus, air compression can be either dry compression or wet compression, depending upon the presence or nonpresence of water vapor in the air during compression. In the other significance air compression is always dry compression and wet compression is impossible with this material except under conditions only obtainable in the physical laboratory. It can be said offhand in ammonia compression that the terms wet and dry compression have to do with the latter significance and are nowhere associated with the presence or absence of water vapor in the material.

Now, dry compression in this latter significance of the term is accomplished whenever a gas is compressed. Wet compression may or may not occur when a vapor is compressed. The difference in the meaning of the words gas and vapor is all-important. A vapor is a gas near the temperature of condensation of the material. Another definition can be stated as follows: A gas is a vapor above its critical temperature. The critical temperature of a substance is the temperature above which a gas cannot be liquefied no matter to what extent the compression may be extended. It will always remain a gas and possess all the properties of the latter. A gas follows Boyle's law and Charles' law in its variation of pressure, volume, and temperature; that is, at constant temperature, the product of the pressure and volume is a constant quantity and this constant according to Charles' law is directly proportional to the absolute temperature of the material. Thus, keeping the pressure or volume constant the other varies in direct proportion to the absolute temperature of the gas. These laws do not hold for vapor, however. The product of the pressure and volume is not a constant for variation of either one in the case of vapors, even though the temperature is kept constant. It is this relative property of vapors and gases which is the ultimate basis of the relative efficiency of wet and dry compression.

Ammonia Compression Complicated

Ammonia compression is complicated still more than the compression of an ordinary vapor by the fact that the compression occurs often at a temperature immediately in the vicinity of the temperature of condensation and often passes through this temperature during the process of compression. In dry compression the work done on the gas in compression is at once evident in an increase in temperature. The quantity of heat produced is an exact equivalent to the work done on the gas and the anomalous condition exists in this compression that the compressor often operates at its minimum efficiency with maximum efficient utilization of work, and the transformation of this work into heat limits very greatly the efficiency of the compression, due to the rise in temperature of the gas, with a resulting increase in the amount of effective pressure required for compression. Thus the object in compression is to compress the gas and remove the heat of compression as fast as produced. It is impossible to do this with any great rapidity and the result is that the heating effect is often cumulative. What is known as cylinder reheating is due to the fact that the cylinder walls become hot on initial compression and upon the opening of the inlet valve again for a second charge, the inflowing gas is at once made hot by contact with the hot cylinder walls. This reheating effect does not result in an increase in the initial pressure of the gas during compression.

The inlet valve is open so that a portion of the gas flows back through this and the net result is a diminution in the density of the gas at constant pressure, or what is equivalent to an increase in volume of the suction gas with a consequent diminution in the capacity of the ammonia compressor for ammonia gas per stroke of the piston. Increase in speed of a compressor only augments this evil and it has been calculated that the capacity of an ammonia compressor is cut fully 20 per cent. in quantity of ammonia gas compressed under normal operative speeds. With increase in speed this factor becomes relatively enormous. Not only does the capa-

city of the compressor diminish greatly but the heating effect continues and results in an increase in average pressure throughout the stroke and a lower efficiency of compression as well.

The jacket of the average ammonia compressor is hopelessly inadequate in the performance of its duty in the cooling of this unit. The heating effect of compression is largely a skin phenomenon limited at high speeds to the intense heating of a thin layer on the interior of the cylinder walls and cooled by recharging before conduction to the water jacket has had time to get in its effect. The old De Lavergne type of compressor, utilizing an auxiliary oil circulation through the compressor, was designed for the purpose of producing an internal water jacket in its effect and for the elimination of clearance evils as well. That the net result was an increase in complexity in the operation of the compressor, with a loss rather than increase in efficiency, is now an accepted conclusion.

Today compressors in which this phenomenon occurs are the common existing type and are the factors which limit the speed of operation and are the greatest limitations on efficiency of the process. The average air compressor is essentially of this type and the evil effects due to reheating and clearance are merely augmented by the presence of water vapor as existing in normal air. Thus, the removal of the water vapor from air presents a form of dry compression, whereas its presence constitutes wet compression, and the effect of water vapor in its influence on efficiency is the determining factor in the two cases. Air and ammonia under these circumstances are two typical gases and dry compression is the resulting phenomenon which occurs in the operation of the compressor.

Now, in the operation of the ammonia compressor it was found possible by injecting a little ammonia liquid into the cylinder on each stroke to keep the material cool throughout the entire period of compression. This does not mean that the heat is not produced. The same, or at least a definite, amount of heat equivalent to the work done is produced on each stroke of the piston. This heat, however, does not result in an increase in operating pressure as it does in the case of gas compression, due to two reasons. One is that the resulting increase in pressure due to heating effect would not be as great in the case of a vapor as in a gas and the other is due to the fact that the heat as fast as produced is absorbed by the vaporization of a portion of the ammonia liquid present in the cylinder. Thus the utilization of this device results in the elimination of two evils, with the production of two additional ones.

Reheating Effect Eliminated

The reheating effect, with consequent diminution in density of the incoming charge and of capacity in the cylinder for the same, is totally eliminated by keeping the cylinder walls cold, but the capacity of the cylinder is reduced in turn by the volume of the ammonia liquid injected per stroke, and the work is increased by the fact that the piston operates against the vapor which is produced by vaporization from the ammonia liquid present in the cylinder when the latter is heated by the heat produced by compression. Thus, the saving is more imaginary than real and is a question of relative efficiencies merely. In dry compression every ounce of ammonia gas which passed through the cylinder was ultimately used for the production of available refrigeration. On the other hand, in wet compression a portion of the ammonia liquid available for the production of refrigeration becomes no longer available for this purpose, since it is evaporated in the cylinder and the heat of vaporization used to produce cooling in the compressional charge during compression rather than in commercial cooling where desired. Thus, the ammonia which passes through the compressor or through the condenser is no criterion or measure in the wet compression system of the amount of refrigeration produced.

While the preceding conditions represent the ideal phase of the wet compression it is not accomplished by any means in practice except under abnormal conditions and is not believed to be the most efficient process. The significance of wet compression is complicated by the fact that there is no real dividing line between the two types. The exact point where the vapor ceases to be a vapor and becomes a gas is dependent upon its critical temperature but this temperature does not enter in many developments. Thus, in air compression the critical temperature is so low that throughout the entire cycle of air changes the critical temperature is never even approached. On the other hand, the critical temperature of ammonia gas is relatively so high that almost throughout the entire stroke it is never approached from the other side.

Again, in ammonia compression matters are complicated by the introduction of what is known as saturated vapor. A saturated vapor is a vapor in contact with its own liquid. Increase in pressure or temperature on such a mixture results in variations in the amount of vapor present, since variations in pressure under such conditions results often in a variation in density without effect upon the pressure or apparent volume. Real wet compression in ammonia is the compression of a saturated vapor throughout the stroke; that is, ammonia liquid is present throughout the entire period of compression. The density of the vapor increases greatly on account of the further production of extra vapor from the liquid during the process. If the liquid injected at the beginning of the stroke is only sufficient to keep the vapor saturated throughout a portion of the stroke, that is, if the heat produced is more than enough to vaporize all the liquid present, then the stroke is no longer absolute wet compression. It is a mixture of wet and dry compression, with the variation between the two not occurring immediately at the complete evaporation of the liquid.

Thus, some wet-compression systems exist in which practically no liquid is injected. The vapor is practically at its condensation point and saturated at the beginning of the stroke, a fine mist of the liquid only being present. This explains the reason why there exists such a variation in possible compressions. In actual practice the conditions occurring inside the cylinder are largely evident from external conditions. The property of ammonia gas is largely a function of the temperature, especially at a given suction pressure. Hence the different phases of dry and wet compression can be readily attained by varying the temperatures of the charge. If the frost is carried back to the inlet valve of the cylinder practically partially wet compression is occurring. If the frost is carried completely over the cylinder so that the water jacket has a layer of ice on its surface, it can be assumed that a portion of liquid ammonia is injected on each stroke, or that the vapor is so saturated with ammonia mist that it behaves in this manner. However, it is possible, with extremely cold condenser water to have this compression occur under these conditions without normal wet compression in the strictest sense of the word. However, such temperatures of condenser water would be extremely abnormal.

The efficiency of a compressor is a function not only of temperatures but also of speed. The result is that the average operating engineer should attempt to get a maximum speed out of his compressor with minimum steam consumption and minimum temperatures on the ammonia gages. Available refrigeration is in every case directly proportional to the work done and hence the speed, if the pressures are the same in the two cases, and it is the generally accepted opinion today that ammonia compressors operate best under normal condenser-water temperatures when the frost is carried back on the suction pipe to within a few inches of the inlet valve of the compressor and the attempt made under these circumstances to speed up the compressor to the extent that the water jacket gets fairly hot or at least is warm to the touch. The frost will invariably slide in one direction or the other without regular attention but it represents undoubtedly the point of maximum efficiency in the operation of the plant.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Hydraulically Operated Valves for Curtis Steam Turbines

The speed of the steam turbine is controlled for different loads by successively opening and closing valves, thereby putting into use more nozzles which admit steam to the first wheel. These valves are of the poppet type, each being closed by a helical spring. The valves are all duplicates and are opened in rotation by cams mounted on a shaft, each cam having an angular lead over that preceding it. The cam shaft is actuated by the piston of an hydraulic cylinder, causing the valves to open so that throttling occurs on opening or closing a valve before the next one opens or closes, thereby regulating the amount of steam admitted for any load.

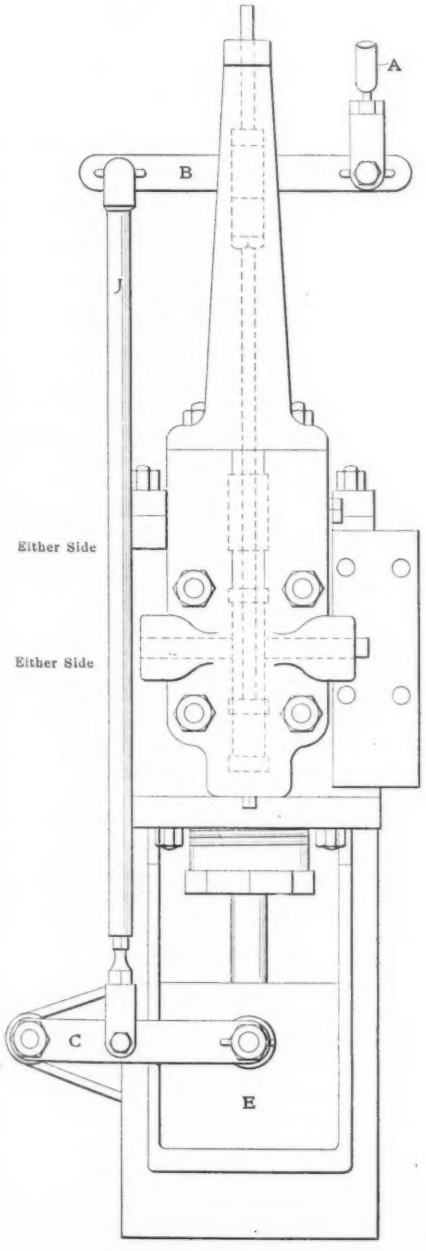


FIG. 1

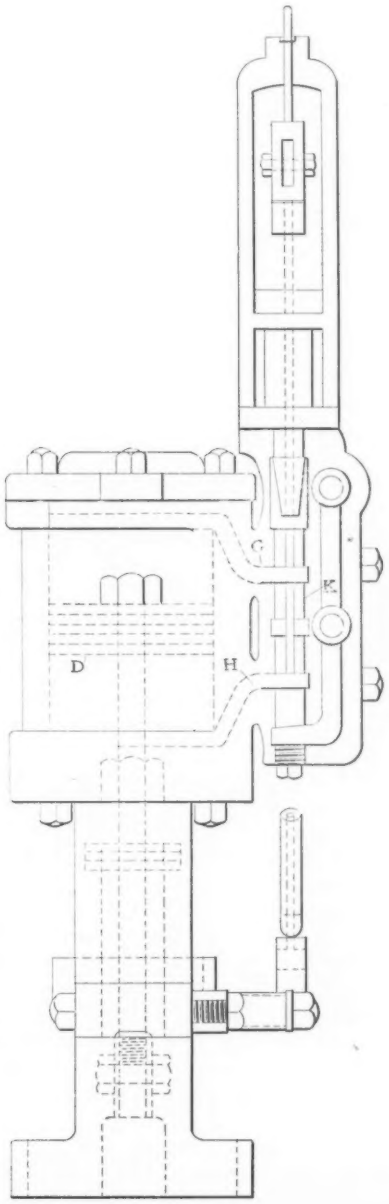


FIG. 2

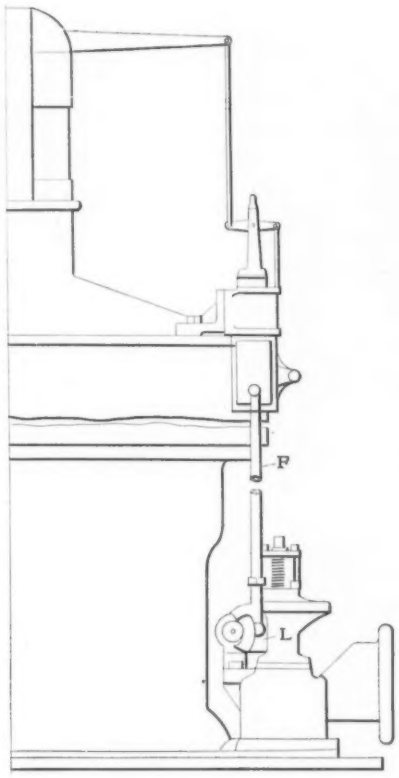


FIG. 3

Referring to Fig. 1, the rod *A* is actuated by the governor, the lever arms *B* and *C* being so arranged that the piston *D*, Fig. 2, will stay in a fixed position to correspond with any position of the rod *A*, Fig. 1, as the crosshead *E* transmits its motion through a connecting rod *F*, Fig. 3, to the cam shaft *L*; therefore, there will be a fixed number of valves open for any position of the governor. While the machine is running at a fixed speed the piston valve will occupy a central position closing both ports, *G* and *H*, Fig. 2. If the speed decreases the governor will move the rod *A*, Fig. 1, down, opening the port *G* to the discharge port and port *H* to admit liquid under the piston, thus opening more valves and thereby increasing the speed. In moving, the piston actuates the rod *J*, Fig. 1, upward and moves the valve *K* to its central position again.

On a good working machine a true valve will drop of its own weight by disconnecting the rods *A* and *J* from the lever *B*. I have experienced some trouble by this valve stem being bent in shipment, thereby affecting its work. It is

necessary that the connections between the valves and governor be free from friction and no binding at any joints, and the liquid must be clean and free from grit for good service.

WILLIAM BUTLER.

Somerville, Mass.

Pressure Required to Lift a Check Valve

Referring to a letter appearing on page 201 of the January 26 number, entitled, "Pressure Required to Lift a Check Valve," I do not agree with Mr. Helms in the following respects:

For instance, Mr. Helms describes a conical poppet double-seat valve so proportioned that the pressure on the front of the valve may equal the pressure on the back of the valve at the moment of opening, the pressure per square inch being the same in each case. This valve, as illustrated by Mr. Helms, is shown in Fig. 1. A recess is cut or cast circumferentially around the valve disk at *a a*, and the fluid pressure is led into this recess through ports *b b*.

Mr. Helms states: "It is evident that if the area of this recess represented by 0.7854 ($d_1^2 - d_2^2$) is equal to the projected area of the seat, 0.7854 ($d^2 - d_3^2$), the valve will open when the pressure per unit area on the front is equal to the pressure per unit area on the back of the disk, since the areas exposed to the action of the fluid pressure are equal on both sides." The weight of the valve disk itself is, of course, neglected in this case.

The point I wish to make clear is this: By referring to Fig. 1 it will be seen that the fluid pressure acting vertically in the recess *a* on a circumferential strip of width *Y* acts up, and reacts down in the recess, and is thus balanced as shown by the arrows and their direction. This pressure, being balanced, has no tendency to lift the valve from its seat. In this case the tendency is to rupture the valve disk itself. Probably this can be better understood by referring to Fig. 2. Here the valve disk is represented as a piston *A* fitted into the cylinder *B*. The diameter of the piston D_4 equals D_4 in Fig. 1. The piston is recessed at *a a*. The dimensions D_4, *Y* and d_2 are equal in both cases.

As before, the fluid pressure is led into ports *b b*. Here it is quite evident that any pressure admitted to recess *a* through port *b* has no tendency to lift the piston, as the forces are balanced vertically. If this is true in both cases, Fig. 1 and 2, there is only the area of a circumferential strip of width *x*, Fig. 1, as the effective area of recess *a*.

The pressure acting up against the strip *x*, reacts down against the sides of the conical valve seat, tending to separate the two bodies. The projected area, or area of strip *x*, equals 0.7854 ($d_1^2 - D_4^2$). This, it would appear, represents the effective area of the recess acted upon by the fluid pressure, and not the area 0.7854 ($d_1^2 - d_2^2$), as given by Mr. Helms.

As the sum of the areas, 0.7854 ($d_1^2 - D_4^2$) and 0.7854 d_3^2, does not equal the area 0.7854 d^2, or in other words, as the area of the front of the disk plus the area of the circumferential strip *x* does not equal the area of the back of the disk, the pressures per square inch will not be equal on both sides of the valve at the moment of opening. Thus, with a valve

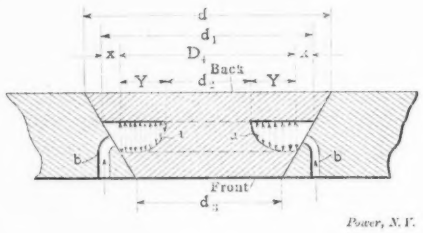


FIG. 1

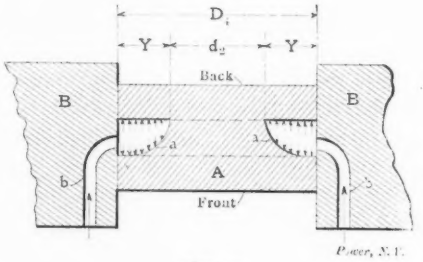


FIG. 2

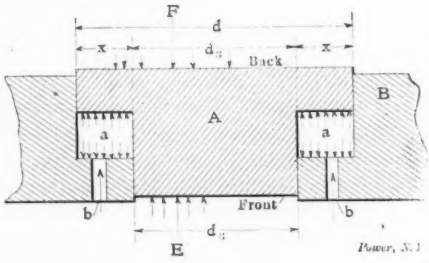


FIG. 3

of this type the pressure per square inch on the front, or under side, will necessarily have to be somewhat greater than the pressure per square inch on the back, or upper side, in order to raise the valve disk from its seat. This is, of course, providing the valve disk makes perfect contact, metal to metal, with the seat, and is not separated by a thin film of the fluid, in which case, neglecting the weight of the disk, the difference in pressure necessary to cause the liquid to flow through the opening should be sufficient to unseat the valve.

If the weight of the valve disk is taken into consideration, the pressure on the under side must necessarily be somewhat greater in order to hold the disk open. Ordinarily, the kinetic energy of the flowing liquid should be sufficient to do this if the disk is not of great weight.

If the valve was arranged as shown in Fig. 3, and the pressure per square inch equal, front and back, the total force *E*, acting up, will equal the total force *F*, acting down, as the areas acted upon by the fluid are equal, both front and back, inasmuch as $d_3 + 2x = d$.

Mr. Helms also makes the following statement: For valves having a circular cross-section the pressure will be equal on both sides at the moment of opening, neglecting the weight of the disk, when the valve is proportional as expressed by the following equation:

$$d_2 = d_1^2 + d_3^2 - d_2^2.$$

This is evidently an error, as the formula should read

$$d^2 = d_1^2 + d_3^2 - d_2^2$$

or

$$d = \sqrt{d_1^2 + d_3^2 - d_2^2}.$$

However, if the foregoing reasoning is correct, this formula will not hold good for the valve in question.

WILLIAM F. FISCHER.

New York, N. Y.

Under the above caption, F. C. Helms, on page 201 of the January 26 number, says: "It is evident that if the area of this annular recess, represented by 0.7854 ($d_1^2 - d_2^2$), is equal to the area of the seat, 0.7854 ($d^2 - d_3^2$), the valve will open when the pressure per unit area on the front is equal to the pressure per unit area on the back, since the areas exposed to the action of the fluid pressure are equal on both sides. For valves having a circular cross-section, the pressures will be equal on both sides at the moment of opening (neglecting the weight of the valve), when the valve is proportioned as expressed by the following equation: $d_2 = d_1^2 + d_3^2 - d_2^2$."

The letters refer to the dimensions shown in Mr. Helm's article. The above equation is evidently a misprint, and from the previous discussion I judge it should read: $d^2 = d_1^2 + d_3^2 - d_2^2$.

What I take exception to is his statement regarding the annular recess. He evidently expects to balance the poppet valve by this recess. Mr. Helms falls into an error when he says the valve is balanced when $d_1^2 - d_2^2 = d^2 - d_3^2$.

To explain this, I have enlarged that part of his illustration, as shown in Fig. 1. This shows the recess when pressure is admitted to the recess through the port *B*. The effective area of the recess that helps to lift the valve is 0.7854 ($d_1^2 - d_4^2$).

To make this clear I have drawn reacting forces at *C* that include all forces in the effective area given above. At *A* I have drawn reacting forces that include all that do not fall in the effective area. As will be seen, the forces at *C* will react

and help lift the valve, while those at *A* will neutralize each other and act as so much dead water.

It will be seen, then, that to fully balance the poppet valve by Mr. Helms' method would require $d_1 = d$ and $d_4 = d_2$, which is a condition not to be considered.

Partially balanced valves have been built on the double-beat principle, see Fig. 2, which is a modification of the idea suggested by Mr. Helms. Let D_1 and D_2 be the diameters of the larger and smaller seats of a double-beat valve, and P the effective pressure of the fluid in pounds per square inch. Then the force required to open the valve equals $0.7854\ (D_1^2 - D_2^2)\ P$, neglecting the width of the seats and the weight of the valve.

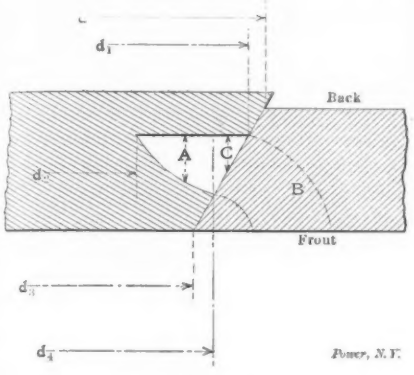


FIG. 1

From this it is evident that by making the difference between D_1 and D_2 small, the force required to open the valve will be small, and consequently the extra pressure required to open the valve will also be small.

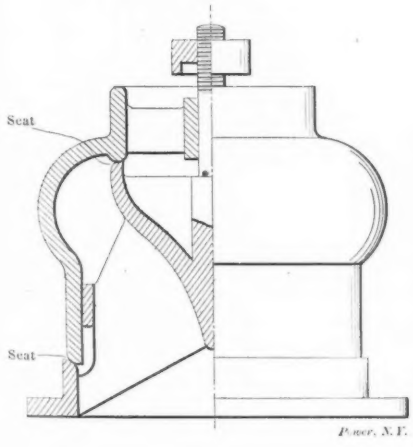


FIG. 2

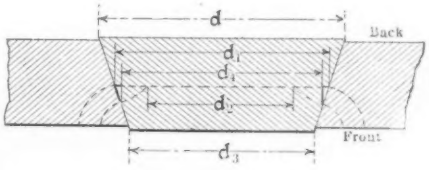
The double-beat valve shown in Fig. 2 was designed by A. F. Nagle, and is now pumping water under an effective pressure of 52 pounds per square inch. The valve is worked automatically by the water. The seats have a ⅛-inch bearing surface, and are made of bronze.

JOHN B. SPERRY.

Aurora, Ill.

On page 201 of the January 26 number is shown a conical or poppet double-seated balancing valve which I think would fail to balance in actual practice. To illustrate the point I take exception to I submit a sketch similar to the one mentioned.

Mr. Helms states that "it is evident that if the area of the annular recess represented by $0.7854\ (d_1^2 - d_2^2)$, is equal to the area of the seat, $0.7854\ (d^2 - d_3^2)$, the valve will open when the pressure per unit area on the front is equal to the pressure per unit area on the back, since the areas exposed to the action of the fluid pressure are equal on both sides." This statement is wrong as he has not taken into consideration the effect of the pressure acting on the area of the surface represented by $0.7854\ (d_4^2 - d_2^2)$, see sketch, which acts in a downward direction opposing the pressure tending to lift the valve. The pressure acting toward lifting the valve should be obtained by $0.7854\ (d_4^2 - d_3^2)$, and is shown graphically by the open triangle in the sketch herewith presented.



MR. COVEY'S SKETCH

T. COVEY.

Albany, N. Y.

Repairing a Crank Disk

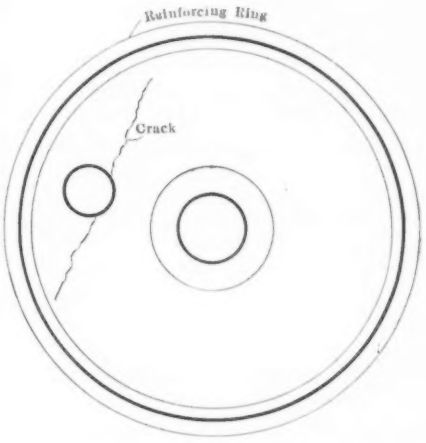
Our main 22x32-inch Watertown simple engine, running at 105 revolutions per minute, began to pound badly and I lost no time in shutting down. When the engine came to a stop I found the crank disk cracked across its face, the crack passing through the lower part of the crank-pin hole and extending to within 1 inch of each edge of the crank disk.

As it would require a week or ten days to obtain a new disk, we decided to shrink on a band. A piece of 2x4-inch steel was rolled and welded into a band and turned up in a lathe 3/64 inch smaller than the disk. After heating the band in an open wood fire, to expand it, we forced it on the disk, and as it cooled it drew the crack together so it could hardly be noticed.

After connecting the crank rod we started up, and the engine ran for about a week, when the crank pin showed signs of being loose in the disk. I took the pin out and prick-punched it all around and drove it in again. I ran it eleven months after that without it showing any signs of loosening.

Then, as we were going to be shut down for awhile the company decided to have a new disk put on. I had a new one cast 4 inches larger in diameter than the old disk, and as the old disk had a hub or boss next to the main bearing 2 inches thick, it allowed the new disk to be cast 1 inch thicker than the old one.

When the new disk was ready, I used live steam from the boiler and heated the disk as hot as possible with steam, which so expanded it that with the aid of four 1-inch rods running back over the hub of the driving wheel it was pulled in place.



SHOWING THE CRACK IN THE CRANK DISK

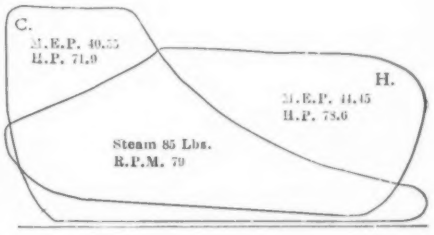
H. L. HIGGINS.

Machias, Me.

Freak Indicator Diagram

The accompanying diagram is from an engine of a type sold by the C. H. Brown company about 15 years ago. The cylinder diameter is 16⅜ inches, stroke 42 inches, revolutions per minute 79 and the steam pressure 85 pounds.

The engine is belted to a heavy jack shaft, and a large amount of the power is distributed by belt and line shafting. For lighting and furnishing power to outlying departments, a 100-kilowatt 110-volt direct-current generator is used, belted to the jack shaft near the engine.



FREAK INDICATOR DIAGRAM

It was desirable to obtain diagrams from the engine without an electrical load, but it was out of the question to shut the generator down. The engineer proposed to switch off the generator for a moment

so that I could get my diagrams quickly, and then throw the generator on again before the motors had stopped. I got the crank-end diagram, but took the head-end just as he threw in the main switch and blew several fuses. I suppose there is some connection between the short-circuited generator and the freak diagram, but have been unable to decide where it lies.

EARL R. FILKINS.

Chicago, Ill.

An Obscure Electric Circuit Trouble

Not having seen any suggestion as to the cause of the arc-circuit trouble of Mr. Minton I would like to make a suggestion as to the probable cause and also explain some of the conditions which probably exist. To begin with, the arrangement of stepping down the voltage from the high-tension lines is not to be recommended, as the arc circuit is electrically connected with them, and the trouble in this case seems to be on that account. It is more advisable to have a transformer with a 11,500-volt primary and an 8000-volt secondary. This would insulate the transmission lines from the arc circuits. The arrangement now is an auto-transformer with an 8000-volt tap.

What I think caused the trouble was a ground on the one leg of the high-tension lines which the auto-transformer is not connected to, and also the high-resistance ground in the underground wires where the lead cable is split and the rubber insulation is deteriorated. As noted, when the stab switch on the regulator side of the arc circuit was inserted, the regulator moved to its extreme position; this could only be expected, as there were but forty lamps burning. It had to act that way to hold the current down. On inserting the stab switch on the opposite side of the circuit, the meter reading there was only four amperes, and to account for this, I think that the current divided at the ground in the underground wire, taking two circuits to the generator; the one circuit which took four amperes went by the way of the lamps and the 2000-volt tap of the auto-transformer, and the remainder of the current went by the way of the grounded arc circuit to the grounded high-tension leg.

It was said that the resistance to ground on the arc circuit was one megohm, but although this ohmic resistance is high, the dielectric strength of the insulation may have been very low, so that when the arc circuit was thrown on the current kept arcing through the small holes in the rubber to the ground, this enabling the ground circuit to form. The discharge of the lightning arrester at the instant of the closing of the arc circuit was due to the ground leg of the high-tension line and also the surge of current through the regulator and the forty lamps. This, of course, happened before the regulator or lamps had a chance to act, thus practically causing an instantaneous short-circuit on the transmission line.

The reason the circuit acted the same way when transferred to the switches of No. 2 circuit was on account of the cause of the trouble not being removed. But when the transformer was changed to a different source of supply, the circuit acted O. K. This proved that the former supply circuit was grounded. An arc circuit can be operated if only one ground exists on the circuit, but it is advisable to get rid of it as soon as possible.

It was not necessary to put a solid ground on the circuit where the cable was grounded to find out if there was a ground between the last lamp and the transformer, because if there was one, it would soon burn itself free or burn up the primary of the transformer, for in a case such as this the 2000-volt primary would be placed across a 11,500-volt circuit. But the solid ground helped out in such a way that it caused two good circuits through the lamps, and instead of the load being on one phase it was thrown across two of the three phases. The circuits formed were as follows: One circuit flowing through the regulator and the forty lamps to ground, the regulator holding the current down so that the lamps would burn; the other circuit was through the primary of the transformer and the other seventy lamps, the voltage per lamp in the latter circuit being greater than normal by about 20 volts at least. If this circuit burned all right, it is probable that the high-tension voltage is less than stated in the sketch. The reason the regulator started to burn after placing a solid ground on the lamps, was because the resistance of the first circuit through the regulator, forty lamps, the solid ground and the grounded high-tension leg was reduced considerably, this overloading the regulator more in this case than before the circuit was solidly grounded.

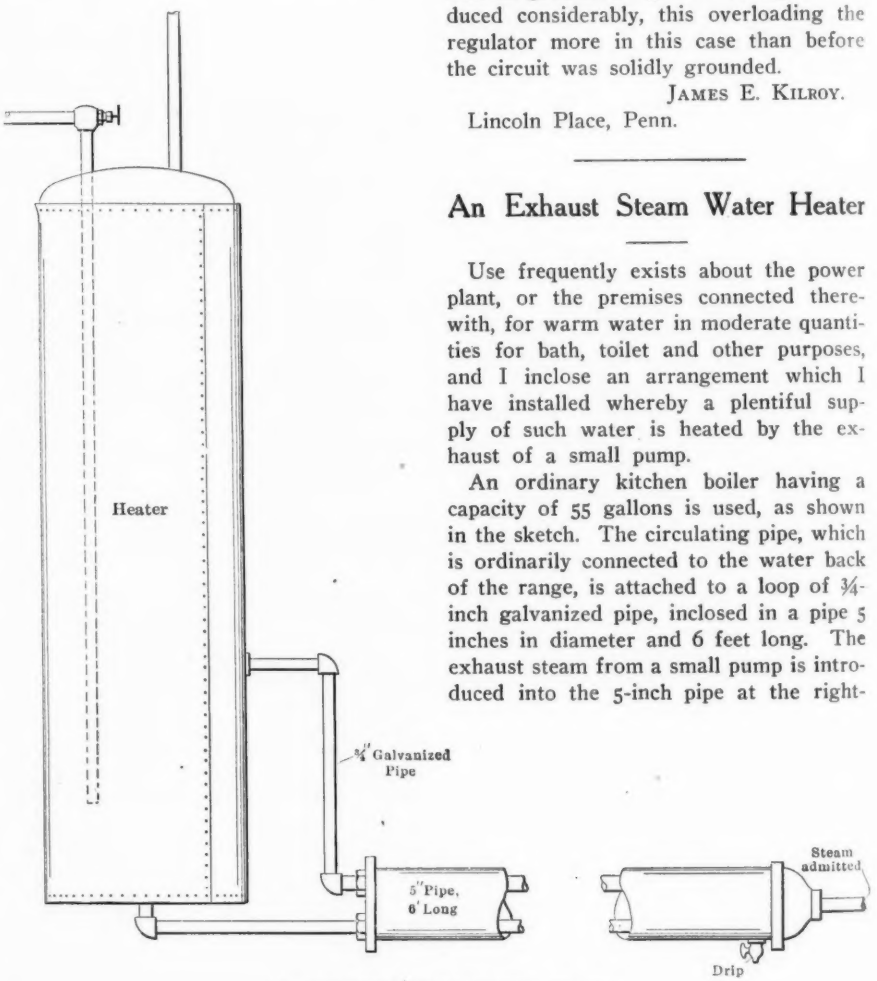
JAMES E. KILROY.

Lincoln Place, Penn.

An Exhaust Steam Water Heater

Use frequently exists about the power plant, or the premises connected therewith, for warm water in moderate quantities for bath, toilet and other purposes, and I inclose an arrangement which I have installed whereby a plentiful supply of such water is heated by the exhaust of a small pump.

An ordinary kitchen boiler having a capacity of 55 gallons is used, as shown in the sketch. The circulating pipe, which is ordinarily connected to the water back of the range, is attached to a loop of ¾-inch galvanized pipe, inclosed in a pipe 5 inches in diameter and 6 feet long. The exhaust steam from a small pump is introduced into the 5-inch pipe at the right-hand end and escapes from a pipe at the other end, as shown, a drip being provided at the lowest point to carry off the water of condensation. The loop is thus always surrounded with exhaust steam, which by heating the water inside produces a circulation, keeping the contents of the boiler sufficiently warm. However little may be drawn from the boiler, its temperature can never rise above the boiling point at atmospheric pressure, and hot water and not steam will come when the tap is opened.



AN EXHAUST-STEAM WATER HEATER

J. A. LOYER.

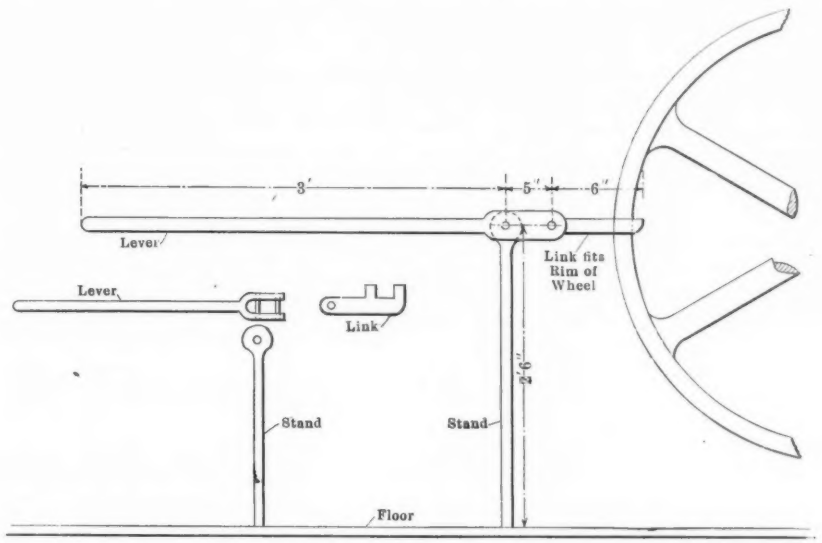
Montreal, Can.

An Engine Turning Device

The sketch shows an engine-turning device I used in one of my plants. It is simple and works well. When one lifts up the lever the link will slide down and grip the rim for a new pull. The illustration shows its construction.

E. A. YOUNG.

Isabella, Tenn.



AN ENGINE-TURNING DEVICE

More Frequent Internal Inspection

The editorial under the caption "More Frequent Internal Inspection" deserves more than passing notice. In considering the value of a boiler inspection two facts should always be borne in mind: First, there are boiler inspectors and boiler inspectors, and they are not by any means all alike. The personal equation plays a very important part in their work; second, the boiler inspector sees the thing from a different viewpoint. He is interested in risks, the boiler owner is interested in economy. It was with the thought of recouping possible loss that the owner in the first place took out a policy. So there you are.

The man who places too much reliance in the boiler-inspector's report is very likely to wake up some morning a sorry man. And this does not presuppose that the inspector did not do his work conscientiously, either. Perhaps he has. Perhaps he has discovered that the tubes are coated with scale, and so states in the report. But the risk is good, and he is not particularly concerned whether you are burning a wee bit more coal because of the scale, and so he says: "Oh, there isn't enough to bother with." Take his word for it, and you'll pay for it in hard cash. But it is to be remembered that there are plenty of cases where scale is present and the inspection has not revealed it. A few concrete cases may be cited.

About four years ago a boiler-tube cleaner was sent on trial to the Petersburg electric-light plant, Petersburg, Ill. The cleaner was tried, ten wheelbarrow loads of scale were taken out "and the boilers were considered by the inspectors to be in good shape," the president reported.

In the May 7, 1908, issue of *Electric Traction Weekly* there was published a paper by A. M. Allen, a consulting engineer. Following is an excerpt:

"As an example, the writer knows of a plant having four 150-horsepower return-tubular boilers, operating twenty-four hours per day, which were pushed to their utmost to furnish the necessary steam, and the insurance inspectors after their examination reported the boilers as being clean. At about this time an enterprising salesman arrived with a tube cleaner which he induced the management to buy. This was put through the tubes and scale taken out by the bushel, the result being that they are now operating their plant on only three of the boilers."

Take another case: Last July, a boiler-tube cleaner was sent to the Clinton prison, Dannemora, N. Y., for trial. Among other things, Mr. Gilbert, superintendent of industries of the institution, in his report stated: "I removed 260 pounds of scale from our No. 1 boiler, and directly after an inspector's report of 'clean boiler' I took out 160 pounds of scale from our No. 2 boiler."

These concrete cases prove nothing if they don't prove that it pays to investigate boiler conditions yourself regardless of what the inspector's report is. You have done a distinct service by touching on this matter.

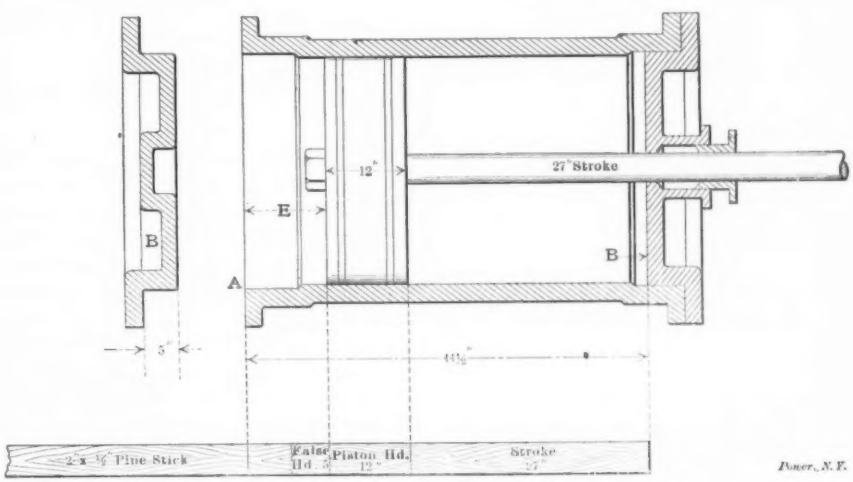
H. E. GANSWORTH.

Buffalo, N. Y.

Method of Adjusting Pistons

To adjust a piston for clearance in a large engine requires considerable hard work. The following is an idea I picked up some time ago that makes it an easy job:

Presuming the piston is out of the cylinder, take a 2x½-inch stick a little longer than the cylinder and, placing it inside against the front head, make a mark at the end of the cylinder at *A*. Say we have an engine with a 27-inch stroke, piston head 12 inches thick, false head 5 inches thick and the cylinder from *A* to *B* 44½ inches. Lay off these measurements on the stick and you have ½ inch left, which represents ¼ inch clearance on each end. When putting the piston in place, adjust it so that the distance from *A* to *C* is 5¼ inches and clearance will be equal on both ends of the cylinder.



METHOD OF PISTON ADJUSTMENT

CHARLES F. BRANDOW.

Mittineague, Mass.

Two Loose Nuts

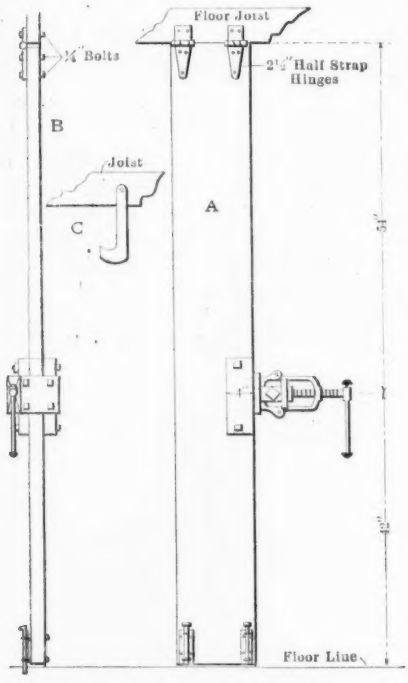
On page 306 of the February 9 number, Mr. Wakeman has a sketch of a Corliss engine, showing the exhaust valves covering the port leading from the cylinder to the valve. This is not correct, as the pressure would force the valve from its seat, resulting in a leaky engine. The valve should cover the port leading to the exhaust chamber; then the pressure would have a tendency to force the valve to seat tight. Also, where will the cylinder head go to when the crank reaches the dead center?

E. L. DEAN.

North Wilbraham, Mass.

Movable Pipe Vise Support

At *A* is shown a front elevation of the device complete; *B* is a side elevation and *C* a detail of the hook for holding the support out of the way when not in use.



A MOVABLE PIPE-VISE SUPPORT

In *A* it will be seen that the pipe vise is mounted on an ordinary 2x12-inch plank, 8 feet long, and at a suitable hight to be convenient to work at. The plank is hinged at the top by means of two ordinary half-strap hinges to the floor joist or an overhead timber. At the bottom of the plank are two 6-inch door bolts which enter plates inserted in the floor and hold the device firmly in a working position.

The vise is bolted to two pieces of 2x4-inch stock, 12 inches long, which are in turn through-bolted to the upright 2x12-inch plank, thus forming a very firm support for the vise with comparatively light material.

The hook shown at *C* is a simple piece of flat steel suitably bent or forged and attached to any suitable overhead support.

When the vise is not in use the floor bolts are raised and the plank lifted until the hook catches it, thus leaving the floor entirely clear for any purpose desired.

EDWIN KILBURN.

Spring Valley, Minn.

Lighting Problem

In the issue of February 2, under the head of "Lighting Problem," F. L. Rolph asks for criticism and remarks on a wiring diagram. The connections shown are feasible. Care, however, must be taken to make the leg of the incandescent circuit, which is also a part of the arc-light circuit, of sufficient capacity so that there is no material drop of potential, thereby lowering the drop on the incandescent circuit. Each incandescent lamp should have a shunt box or coil, so that the burning out of one lamp will not put out the others, nor increase the voltage across the others; or some other device must be used so that when the lamp burns out the circuit will not be interrupted and additional resistance will be introduced in the circuit to make up for the loss of this lamp.

With reference to commercial circuits, unless it is possible to divide the load fairly evenly between the circuits, I should recommend the use of three wires on each side in order to make this division of load possible, and thereby keep the regulation fairly close.

HENRY D. JACKSON.

Boston, Mass.

Why Some Engineers Do Not Read

When I read a letter recently under the above heading it directed my thoughts back to my first experience in engineering, under a chief. Being deeply interested along engineering lines, I procured some books and began to study at home. Then I enrolled as a student in a correspondence school. Finally I secured a job as fireman in a light and power plant in a town of about 13,000 inhabitants.

Thinking that I was now fairly on my way for advancement, I studied harder than ever and began to read technical papers, and could see the benefit gained by so doing. But unfortunately I was under a chief who condemned books and papers and claimed that there was nothing in them. He said that he "had a head that told him things," etc., but I went ahead just the same, received a promotion and finally secured the management of a municipal plant in a neighboring town, a position I never could have held without study. I still read POWER AND THE ENGINEER, especially the practical letters, and derive much benefit from it.

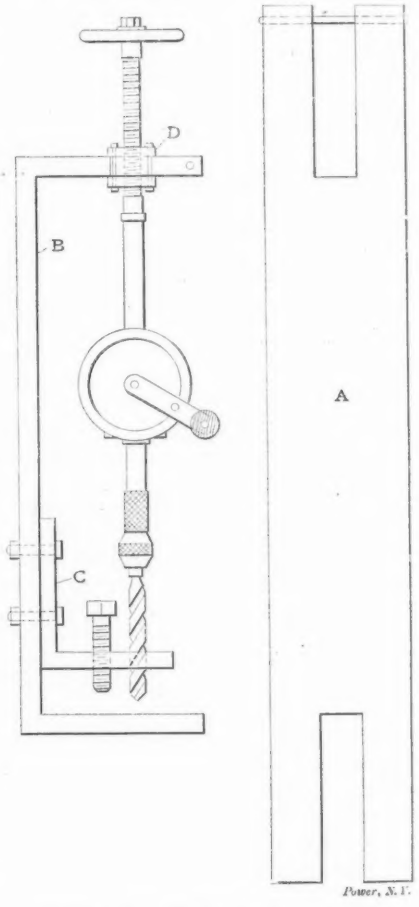
After a few inexcusable delays our friend, whose head told him everything, was asked to resign. He then got into a little plant in a town of about 600, but after a few months he had that plant shut down, and he was looking for another position. It pays to read technical papers.

E. H. CAVANAUGH.

Altamont, Ill.

Using a Breast Drill

The accompanying sketch shows how a breast drill can be used to good advantage. Having to drill a great many holes, I fitted up the drill in the manner shown.



USING A BREAST DRILL TO ADVANTAGE

I took a piece of ⅜x2-inch cold-rolled steel *A*, and after sawing slots in both ends, bent it as shown at *B*. Next I took a piece of the same stock and sawed a slot in it and then bent it at right angles, as shown at *C*, and bolted it to the frame piece. A couple of set screws were provided to clamp it to the work to be drilled. I then took two ½-inch nuts and sawed them out to fit the slot, as shown at *D C*.

A 1-inch shaft was then turned out with a head and one end threaded to fit the nuts. The other end was turned down to fit a collar, which in turn fitted

the shoulder of the breast drill. A pin prevents the nuts from sliding out of the frame.

G. A. CLEVELAND.

New Haven, Conn.

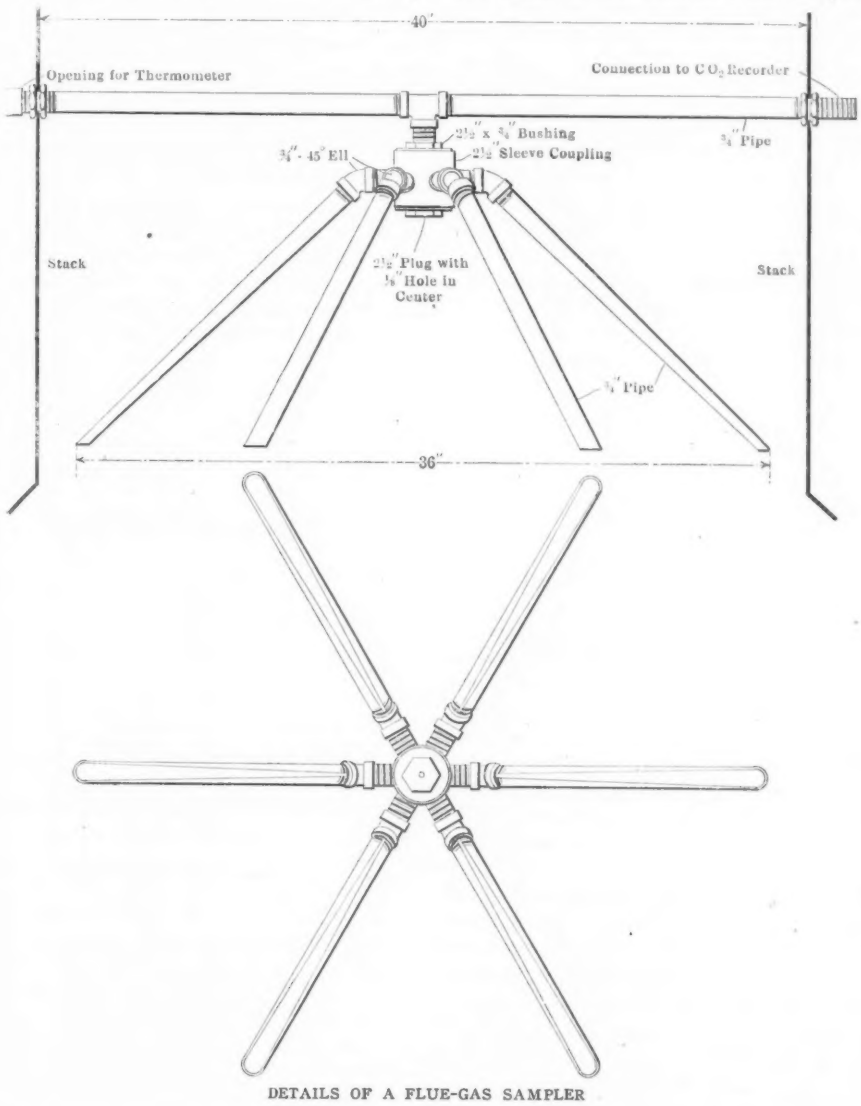
Flue Gas Sampler

Sampling tubes for collecting the flue gases for analysis with the CO_2 automatic recorder, or with other analyzing instruments, have always given more or less worry to the operator. If they do not become stopped up with soot, there is always the question as to whether an average sample is being obtained.

After using the American Society of Mechanical Engineers' flue-gas sampler, as described in volume 21 of the *Transactions*, page 92, for some time, it was discarded on account of soot and small particles of ash collecting in the small tubes and solidifying to such an extent that they could not be removed by blowing through with steam, thus closing the openings; the advantage of this design being thereby destroyed, as the sample was no longer an average one.

While we had better success with a single ¾-inch pipe, reaching across the stack, with a number of ⅛-inch holes drilled in the under side, throughout its length, with the end capped, there was always the doubt as to whether a proper sample of the gas was being taken.

The line sketch herewith shows the design of sampler now in use. This sampler is made up entirely of pipe and standard fittings, and is so constructed as to collect gases from all parts of the stack and mix them in a mixing chamber before going to the recorder; the sampler being placed in the stack just below the damper.



DETAILS OF A FLUE-GAS SAMPLER

The mixing chamber is a 2½-inch sleeve coupling, with a plug in its bottom having a ⅛-inch hole in its center. In the top of this sleeve is a 2½x¾-inch bushing and a ¾-inch nipple to which the sampling tube is connected by means of a tee. The sampling tube extends across the stack, forming a hanger for the entire apparatus, and at the same time giving an opening in which a flue-gas thermometer can be inserted. Six holes are drilled in the mixing chamber and tapped for ¾-inch pipe, to which are attached six legs, as shown. The pipes forming the legs have a slotted opening on the under side, decreasing in width toward the mixing chamber, making a slot the width of which at any point is proportional to its distance from the center.

This sampler has given good results after nine months' use, and up to the present shows no signs of clogging with soot and ash. The line on the chart is much more regular than the line obtained from the use of the single-tube sampler, and resembles the line obtained from the use of the A. S. M. E. "code" sampler.

O. L. HOWARD.

Annapolis, Md.

Rope Drive for Governor

In the issue of January 26, R. McLaren comments on the governor drive mentioned in a previous number. Answering his letter, I would say that the rope drive previously mentioned not only reduces the liability of losing the driving power due to a possible break but, what is more important, there is much less liability of slippage, even should the ropes become oily. Each rope as it passes over the sheave is firmly held, or I might say wedged, into a V-shaped groove, and each rope is alone capable of driving the governor, so that the slippage, even under very unfavorable conditions for a belt drive, is almost negligible with the rope drive.

Mr. McLaren mentions "freezing," which I take to mean gripping of the governor spindle due to heating caused by friction. In a properly built governor the fits are made such that this is almost impossible. The friction of the governor is very small and if it is properly oiled it can easily be turned by hand. Under ordinary conditions, the usual belt is a more than sufficient drive, though far less reliable than the rope drive.

Roller bearings are not necessary in a properly designed governor. Most manufacturers support the spindle on two hardened-steel buttons, or on a brass button between the steel buttons. In the latter case a set screw is provided underneath to take up the wear on the brass.

One of the objects of my previous letter was to point out the "safety-stop" fallacy. The term "safety stop" is a misnomer; the attachment is a "convenience device" with a hazard attached. An engine would be more safe without it, especially when there is excessive governor slippage. Usually engines run over, and the tight side of the belt is on top, so that Mr. McLaren's suggestion as to the convenience-device adjustment would, in most cases, be ineffective.

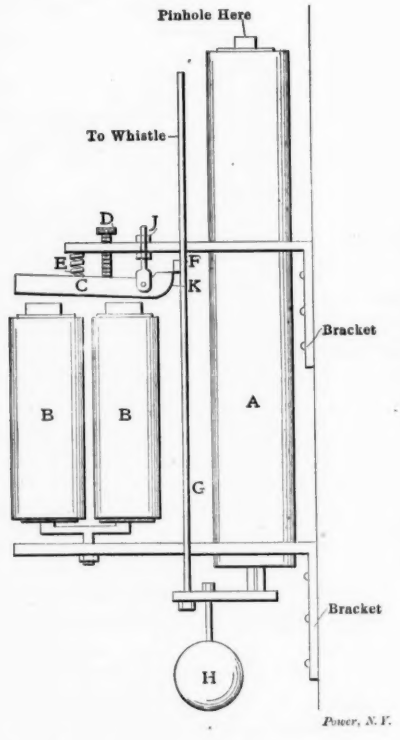
CORNELIUS T. MYERS.

Corliss, Wis.

Automatic Device for Sounding Whistle Alarm

The accompanying sketch illustrates a device which is connected in series with an annunciator on the battery side of our fire-alarm system for the purpose of automatically sounding the whistle in case of fire. The magnets *B B* are connected in series with the annunciator, and in case an alarm is turned in from any station about the works the armature *C* is drawn downward, thus operating the catch *K* and releasing the rod *G*, which is drawn down by the weight *H*, the weight being sufficient to pull the whistle.

The descent of the rod is regulated by the dashpot *A*, which prevents it from descending with a jerk. When the circuit is opened again the armature is lifted by the spring *E*, which is just strong enough to raise and support the weight of the armature. The rod and weight are then raised by hand ready for the next call. The air gap between the armature and the magnets is regulated by the set screw *D* and hanger *J*.



DEVICE FOR SOUNDING WHISTLE ALARM

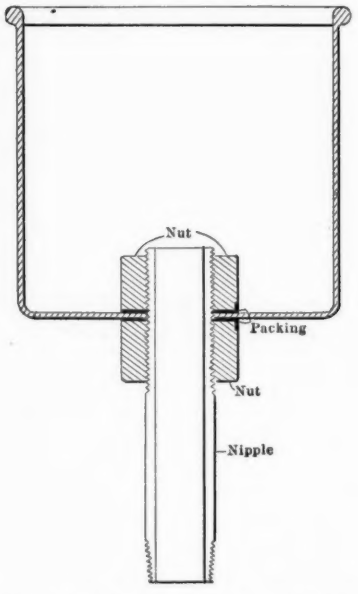
The parts *F* and *K* are made of hardened steel, the armature of soft iron, and the rod and hook, at the bottom, are made of steel; the dashpot, hangers, set screw and brackets are made of brass. The magnets were taken from an old alarm bell. This device works very well and is substantial. The system is tested at regular intervals to insure its being in working order.

L. U. Hawkins.

Reading, Penn.

Piping Vessels Without Threading or Soldering

Following is a kink in piping vessels that cannot be tapped or soldered: A hole is cut in the vessel, through which a piece of pipe of the size to be used is passed. A long screw nipple is secured by two locknuts. One nut is removed and the other screwed down to the shoulder of the long screw, with the counter-



PIPING A PAN, BUCKET OR OTHER VESSEL

bored side facing the long screw end of the nipple. After passing the long screw end of the nipple through the hole in the vessel from the outside, screw the other locknut on with the counterbored side toward the bottom of the vessel. Then wind a piece of lampwick or other packing around the nipple on both sides of the vessel, between it and the locknuts, and screw them up tight.

Piping can be run from the end of the nipple to any desired place. We use this joint in running pipes from oil tanks to various parts of machines and engines, and find it very satisfactory.

F. E. Fick.

Govans, Md.

Transformer Connections

In the issue of February 2, under the head of "Transformer Connections," R. S. Carroll asks if, having two transformers connected in open delta across phases *1* and *2*, it would be necessary to install the lighting transformer across phase *3*; also what effect it would have on the regulation.

Since without the lighting transformer the circuit would be balanced, it would make no difference on which phase the lighting transformer was installed, as this would be the only unbalancing feature of the circuit. The effect on the regulation, therefore, would be dependent on the size of the wire used on the phase on which the lighting transformer was installed, and the loss in this wire. Since the lights are used when the motors are not, the regulation would be entirely dependent on the regulation of the transformer and the size of the wire. The motor-circuit regulation would be dependent, also, on the same conditions.

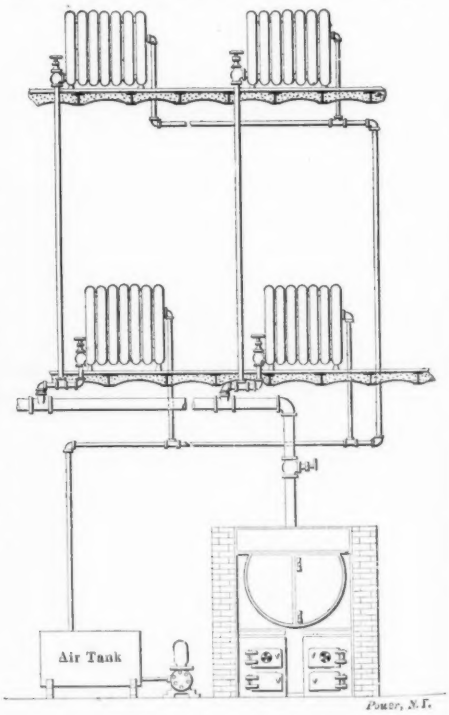
Henry D. Jackson.

Boston, Mass.

Substitute for Air Valves

The accompanying illustration shows the arrangement of my heating plant and my method of preventing water hammering in the pipes and radiators. All air valves have been removed and instead I have connected a small ⅜-inch air pipe running parallel with the steam pipe. This air pipe extends from the various radiators to the basement and connects to an air tank after combining in one 1-inch pipe.

In the morning I open the valve on the 1-inch pipe and leave it open until I get



ARRANGEMENT OF HEATING PLANT

4 or 5 pounds of steam on the boiler, when the valve is closed. I keep up steam until about 11 a.m., by which time there is considerable condensed water in the air pipe at the lower end, and there has also formed a strong vacuum between this water and the radiator. The vacuum in the air pipes will draw the vapor out of the boiler, and the radiators will remain hot all day. I can steam up any time during the day and there is absolutely no water hammering. I have 82 radiators in

the building, and in cold weather the air valves would generally freeze, keeping me running around opening up air valves instead of attending to the boiler. I put in 1736 feet of air pipes, arranged as shown. At the air tank is a belt-connected pump driven by a gasolene engine for removing the condensed water.

N. H. JORGENSEN.

Sleepy Eye, Minn.

Babbitting a Large Main Bearing

In response to a hurry-up call, a machinist was sent to babbitt a main bearing. The engineer had neglected the bearing during the night run and, from some cause or other, the babbitt had melted, so that the shaft was wearing down into the iron of the bottom box before the engine was stopped.

A piece of sheet iron a little longer than the bottom box was bent, as shown at *A*, Fig. 1, and fastened to the box by means of clamps, leaving an opening of ¾ to ⅞ inch for the babbitt. Another piece was bent as shown at *B* and fastened to the quarter box, allowing room for the babbitt metal. The boxes were stood on end on an iron plate and the bottom well sealed with clay to hold the babbitt. A little tallow from a candle was scraped into the cavity to prevent an explosion, and the boxes poured. When cool, the sheet-iron forms were removed and the babbitt well hammered with a ball-peen hammer.

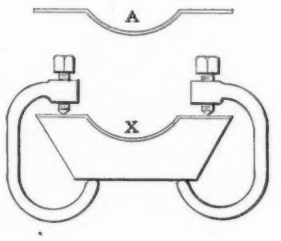
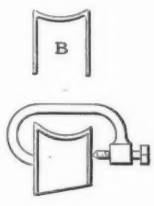


FIG. 1



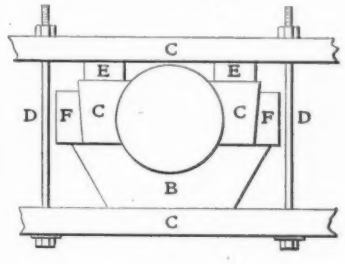


FIG. 2

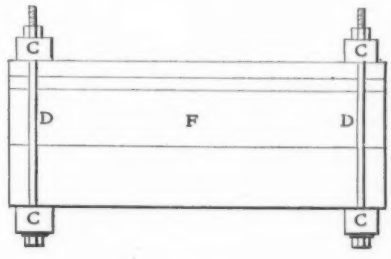


FIG. 3

The boxes were then assembled as shown in Fig. 2 (end view) and Fig. 3 (side view). The pieces *C C* are of hardwood, the bottom ones being of the required thickness to bring the center of the box to the same hight as the center of a lathe. The bolts *D D* hold the bearing together and also clamp it to the lathe carriage. The pieces *E E* were made of hardwood, and high enough to enable the cutter to clear the pieces *C C*. Care was taken to have the distance across from the outside faces of the wedges *F F* the width of the opening in the frame. A boring bar was placed in the lathe. The boxes were then set, bored out, oil grooves cut, and the surface scraped.

E. G. HADDIX.

Burlington, Ia.

Dashpot Does Not Seat

In endeavoring to answer the query of Elsworth Davis under the above caption, on page 200 of the January 26 number, I will say that it is very difficult to suggest the cause of the trouble from the meager particulars given. Requests for information in reference to matters of this kind should be accompanied with some details, such as type of dashpot, the make of engine, whether of old or late design, etc. For instance, the dashpot and plunger of the old Hamilton-Corliss, and the later engines of this same make, are entirely dissimilar.

The old Hamilton, as well as other Corliss engines made at this time, employs a type having two plungers in one, the smaller having a cup leather on it, and this has for its office the formation of the vacuum for pulling down the plunger after the knockoff cam has caused the release of the die from the block. The upper plunger is much larger, and has a leather riveted on its under side. This leather has a small flap valve working over a small port bored in the plunger. The object of this plunger is to cushion the plunger on its descent to prevent it from slamming or striking the bottom of the dashpot. As the plunger rises, this little flap valve opens and allows the air chamber to fill with air, and in the air chamber of the dashpot proper there is an air-exhaust regulating valve. When this is properly set it will allow all of the air to escape except just enough to cushion the drop of the plunger. When the plunger has risen and the block is released, allowing the plunger to drop, the little flap valve closes, so that the air admitted through it cannot escape through it, and hence can escape only through the regulating valve.

Now the trouble may be caused by the cup leather having become worn too much, or having become defective from any other cause, so that the necessary vacuum is not formed under it. Or, what is more likely, the leather on the cushioning plunger, or the plunger itself, may have become worn and defective, or the little flap valve may be defective. This last is the most frequent cause of the trouble. If it has become defective it makes it impossible to regulate the cushion.

I have had this trouble when the dashpot would work all right when using the starting bar, and would work good and bad by turns when running. The only sure way to locate the trouble is to dissect the dashpot, having secured a knowledge of the functions of each part and the condition each part must be in to perform its functions properly. If this does not lead Mr. Davis to a solution of the problem, my advice would be to take it up with the builders of the engine, giving full particulars. The times I have been helped by the builders of engines are many. They are the best friends of the ambitious engineer.

WILLIAM WESTERFIELD.

Lincoln, Neb.

On page 200 of the January 26 number, Elsworth Davis tells of his trouble with a dashpot not seating with a light load on the engine. If he had stated what kind of dashpot it was, whether leather-packed or otherwise, what his full engine load was and how fast the engine ran, perhaps readers would more clearly understand the nature of the trouble.

I have had the same kind of trouble, but the dashpots were of the leather-packed type. Every time the leather got the least bit worn air would leak in and partially destroy the vacuum in the dashpot, and the dashpot would not seat until the hook forced it down.

There are several things that will cause this trouble; too much compression, too high speed with low boiler pressure, too high receiver pressure, or too late cutoff, causing the dashpot to rise too high. This latter mostly caused the trouble I had.

Mr. Davis says that by working the wristplate by hand, the dashpot works nicely. Perhaps he does not move the wristplate as far by hand as it travels when hooked up with the engine running. That will make a great difference, as the governor and knockoff cams are not in the same position when stopped as they would be while running.

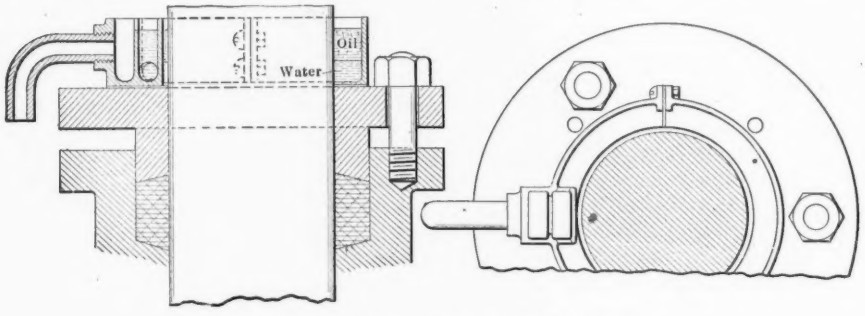
GEORGE W. HARDING.

Lexington, Neb.

Method of Lubricating Elevator Plungers

While the plunger elevator is being discussed in the columns of POWER, I submit a sketch showing a method I have used to lubricate the plungers of elevators, pumps, accumulators, etc. I found that oil keeps a plunger in better condition than grease, but is easily washed away by leakage from the stuffing box. To prevent this, I attach a collar to the plunger and gland, which retains the oil and acts as a separator, permitting the water to escape through the drip. The plunger in moving up or down carries the oil on its surface, thus keeping the plunger free from gum or corrosion and also preserving the packing.

Should any water leak by the packing, it will pass through the opening near the bottom of the ring and overflow to the drip pipe. The sketch shows the ring made in two pieces to facilitate its application.



METHOD OF LUBRICATING ELEVATOR PLUNGERS

W. H. O'CONNOR.

Newark, N. J.

The "Contraflo" Condenser

In the article on "Development of the Surface Condenser," in the February 16 number, at the bottom of page 347 the statement is made: "In order that the air pump may extract the greatest quantity of air from the condenser, it is necessary to remove the vapor with which the air is mixed." A clearer statement would be as follows: In order that an air pump may extract the greatest quantity of air from a condenser its temperature must be low relatively to the temperature in the condenser, for to remove a given weight of air it is also necessary to remove the vapor with which it is mixed.

On page 348, in the first column, it is stated that "The sealing water, after passing through the air pump, is returned to the cooler, so that the same water is used over and over again." This statement is true as applicable to a dry system, where the water of condensation is not dealt with by the air pump, but by a separate pump. It does not apply to the design illustrated in the article, however.

Although the Contraflo Condenser Company, of London, is the manufacturer of this condenser, the Elwood Company is not the selling agent in the United States, but the representative to authorize the manufacture of the "Contraflo" condenser, under license, by any reputable builder of this class of machinery in the United States.

THE ELWOLD COMPANY,
W. R. Molinard, Manager.
Philadelphia, Penn.

Getting Complete Combustion

It seems to be the general opinion of most all authorities on smoke-consuming devices that the gases must be brought into contact with a white-hot arch of firebrick before passing onto the shell and tubes, in order to get complete combustion.

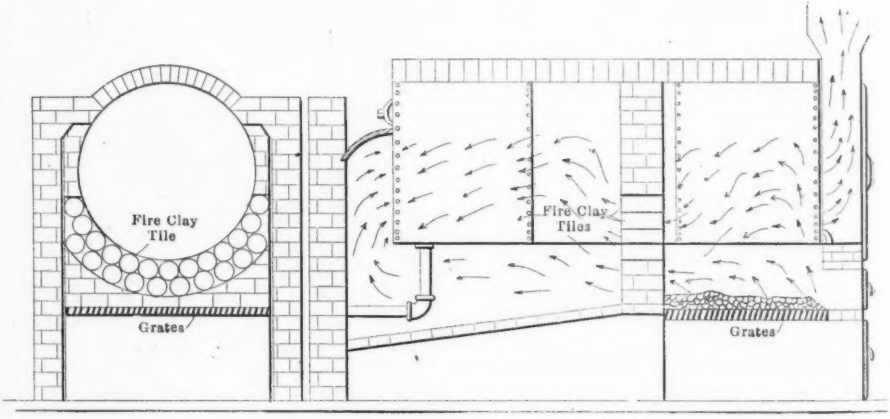
In the ordinary boiler setting the main body of the gases passes directly from the grates over the bridgewall, along the comparatively cool surface of the shell and into the tubes, without any direct contact with the furnace walls, naturally resulting in a rapid cooling of the gases. These pass off in the form of smoke, which could be consumed if the proper amount of air was admitted to the furnace and divided into small streams, coming in contact with a surface hot enough to ignite the mixture.

The sketch illustrates a method that could be applied with very little change or expense to any ordinary boiler setting to get this result. End and side views of the furnace are shown. The space over the original bridgewall is filled in to about the center line of the boiler shell, with fire-clay tile, the bridgewall being round to conform with the boiler curvature. This causes all gases to pass through the tile, which is at a white heat, before reaching the combustion chamber.

If necessary, in order to get the proper mixture of air before the gases enter the tile, air jets could be placed in the front of the bridgewall and a steam jet used to inject the proper quantity of air, although I think sufficient air could be admitted through the furnace doors and over the fire to get proper results, at the same time keeping the temperature of the door and surrounding wall down. The space between the bridgewall and boiler should be made large enough not to restrict the draft by the space taken up by the tile.

S. KIRLIN.

Fort Smith, Ark.



END AND SIDE VIEWS OF FURNACE PROPOSED TO SECURE BETTER COMBUSTION

Fixing Loose Crank Pins

I have read at different times how engineers have fixed loose crank pins by riveting the end over, center punching the pin around the end near the outside, or driving in dowel pins. One may in this town cut a keyseat in the pin and drive in a key.

Professor Sweet's scheme is, in my opinion, the best, that of drilling a hole in the center of the pin and driving in a taper tool-steel pin.

My scheme to cure a loose crank pin is to put in a new one. It is not much of a job to make a new pin, and if an engineer has not the ability to do it he has no business with a job of any importance. If a pin is loose in the fit, center punching, etc., will not make it tight.

JOHN DUNN.

Streator, Ill.

Some Useful Lessons of Limewater

The Gases in the Air and the Part They Play in Combustion; Interesting Experiments to Prove That When Coal Burns It Forms an Acid

BY CHARLES S. PALMER

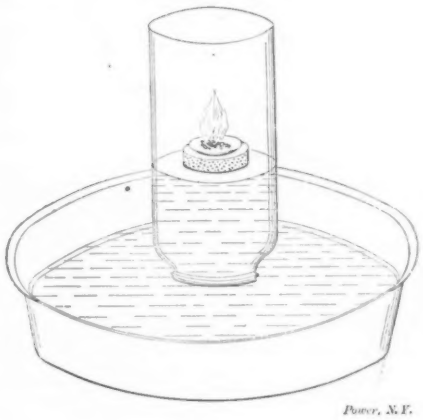
All that we have studied thus far is only an introduction to what that barrel of quicklime has to tell. We have seen that lime-like substances are found in hard water and that, sometimes, it is one of these same lime-like things which may be used to overcome this hardness; as though one should make one hand wash the other; or, following the old proverb, healing by "a hair of the dog that bit him." But this subject of hard water, while very real and practical, is not a separate thing by itself; it is connected with many other chemical facts and theories. We will make short excursions into some of these other fields, such as that of fire or water, or that of acids or alkalies.

Fire

In making our clearing before our imaginary cabin home, in the forest of ignorance and prejudice, one of the first things which we should know something about is the air, or the atmosphere, as it is also called. We know that the air has everything to do with burning, for if we want to make a fire burn in a stove or furnace all that is necessary is to keep the grate free from ashes, supply it with fuel, light it and give it free draft. Indeed, in some forms of power maker one can almost control the engine by regulating the doors and dampers. So it is almost self-evident that burning, in the common meaning, is dependent on the air draft.

Moreover, when coal or fuel burns there is some great change in the fuel. Most of it goes up the stack, except some 5 or 10, or, perhaps, 15 or 20 per cent. of ashes; but usually from 80 to 90 per cent. of the fuel vanishes in the work of furnishing heat and power. If one should look only at the fuel and the remaining ashes he would suppose that burning is a subtraction; and there was once common among scientific men a theory which called itself "phlogiston," that is, "burn stuff," and which supposed that burning is a subtraction, because they looked only at the fuel and ashes. But if we look with one eye at the fuel and the ashes and save the other eye for the waste gases which go up the chimney, then we find that *burning is an addition*, and not a small addition but a great addition. This is proved by burning fuel in closed apparatus and weighing everything which comes off it. In this way it is found that one ton of hard coal will send up the chimney, when well burned, between three and four tons of burnt gas, to say nothing of wasting heat on some nine or ten tons of a gas (nitrogen) which is in the air as neutral "filler."

If your attention has never been called to these curious facts, you have a good right to be skeptical as to the correctness of the figures. They are only general, but they are approximately correct; and you begin to think that our eyes must be half blind to let such vast quantities of substances slip by us unnoticed. There are many ways of getting at these interesting things, but one of the easiest ways is to ask this simple question: Is the air about us composed of one thing, or of several things? You have heard all your life that the air is mostly made up of the two gases, nitrogen and oxygen; but if



Power, N.Y.

FIG. 1

you have not taken this statement in the forceps of your careful attention, if you have not tested this statement with your own chemical apparatus, you can have but a faint notion of the wonderful meaning and the good business value which lie hidden behind the simple statement that the air is made up of nitrogen and oxygen. You know that there is more of the nitrogen than the oxygen, and yet that the oxygen is the active thing as far as burning is concerned; but you need to prove at least a part of this for yourself, in order to see what the fact is worth to you.

Two Things in the Air

Take a common wash or dish pan, as shown in Figs. 1 and 2. By the way, you will be flattered to know that your wash dish is serving for what the books call a "pneumatic trough;" which means a contrivance for handling gases, a simple but great invention. Put an inch or two of common water into the dish. Get a wide-mouthed jar, say a common fruit jar. Find a wide, flat cork, which will easily pass through the mouth of the jar, without touching the sides, and float the cork on the water in the wash dish. Now find a little saucer-shaped dish to ride on the cork and to hold some easily combustible stuff, such as match ends, sulphur or phosphorus. The cork must lie flat and well balanced with its cargo of stuff to burn; and sometimes it will be more stable if the wider end of the cork is at the bottom. You will find that you must get this point well fixed, as you have got to place the jar mouth downward over the cork and its cargo without disturbing the latter. Any saucer-shaped piece of tin or iron, as the round cover of a spice box, will do for the little dish; sometimes the saucers and plates of a doll's tea set serve first rate for such purposes, or the little dishes in a common box of water paints. You want to get the cork and its load well balanced, so you can slip the wide-mouthed bottle down over the cork. Then light the phosphorus or match ends, or what stands for your quick burner, and neatly put the bottle mouth downward into the water and over the burning cargo on the floating cork. As it burns, there will be an escape of several bubbles of air from the bottle, and you can explain this by the sudden heating of the air shut up in the bottle. But pretty soon the fire in the dish on the cork will burn more slowly, and finally it will go out. Meanwhile the cork, with its cargo, has risen up and into the jar, as the water absorbs and cools the air inside the jar.

Now note the air in the inside of the jar or bottle. It is thick with smoke and fumes; but these will be partly absorbed by the water in the bottle, for the water will rise part way up the side of the jar or bottle (Fig. 2). You want to perform this experiment over and over again, so you will get rather expert in handling what will soon seem clear and simple to you. You will note that if you use nearly pure phosphorus from match ends, or with some sulphur from eight-day matches, or with some powdered sulphur or brimstone scattered on, you will get more absorption of the fumes remaining in the jar after the burning. When you use wood or paper, coaxing it with a few

drops of kerosene, you will not get as much absorption of the burnt fumes by the water. But in every case, with the burning of phosphorus you will get an absorption of the air in the bottle by the burning amounting to from one-fifth to one-third. The correct figure is about one-fifth; but you may drive off too much air at the start from the expansion from heating, before the real burning has gone very far; and this error in the experiment will show up as an apparent absorption of the original air greater than the real absorption and disappearance of the air in the bottle.

There are several sides to this experiment, and we will mention them here, so that you can be on the lookout for them:

First, the strong burning of the stuff in the little saucer, and the placing of the jar over this.

Second, as soon as the fire has gone out in the saucer and the water in the jar has finished absorbing the fumes from the burning, lift the jar quickly out of the water, first slipping a piece of cardboard over the mouth to keep the water that is in it from flowing out. Shake violently, using the cardboard cover, and set the jar right side up on the table. Note the amount of absorption of the original air in the jar.

Third, light a splinter of wood and thrust it quickly down into the air left in the upper part of the jar; the splinter is put out, as anybody should know it would be, because if the fire of phosphorus went out, wood or paper would not burn well in this same residual air. All the same, it is not a foolish thing to do, to test this same residual air with your splinter of wood. It sets you to thinking what it all means and you begin to note that there must be different kinds of gas as regards their ability to help burning. The gas oxygen that has gone off (it has gone into the water) helped the burning), and it amounted to only about one-fifth by volume of the whole air. The part of the air that is left will not help common burning, although it makes up some four-fifths by volume of the air; this remaining part is nearly all nitrogen. Just to set your mind at rest, you may like to know that there are three other things in the air in small quantities. These are some water vapor, some of your old friend carbonic-acid gas and a strange newcomer, called argon, the "lazy element," because it does not do anything but exist; that is, it does not make any definite compound with anything, but sometimes pretends to be like nitrogen as it is found in the air, about one part in a hundred by volume.

Fourth, put some litmus into the water at the bottom of the jar and note the action. Of course, you know enough by this time never to take one piece of litmus paper, nor one color, but *two* pieces; or, at least, one piece colored red at one end and blue at the other. You can take a bit of red litmus and let one-half touch a piece of soap to blue one-half. With both red and blue litmus you can catch both alkalies and acids. You will find that the water in the bottom of your jar turns the litmus red; that means that the burning has made something which went into the water and which has acid properties. If you used mostly phosphorus then the burning of the phosphorus has made one kind of phosphoric acid. If you used mostly sulphur in burning in the little dish on the cork, then the burning mostly made sulphurous acid, with some sulphuric acid. But in both cases, the burning with the oxygen of the air made things that are essentially acids. It was the great French chemist, Lavoisier, who found this out some hundred and forty or fifty years ago, about the time of the Revolutionary war; he showed that burning was an *addition,* and that the adding of the "burn-helping" gas (oxygen) in

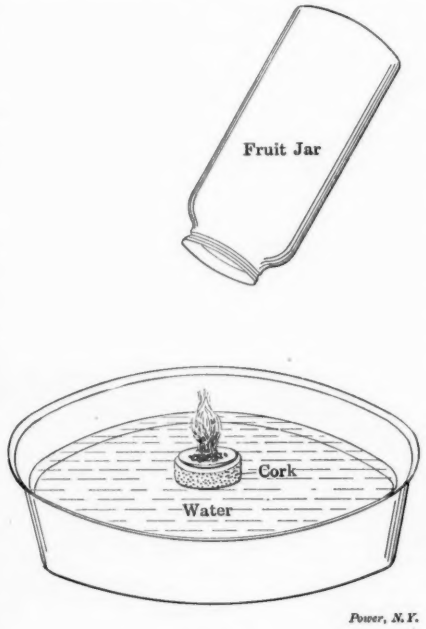


FIG. 2

the air to the things burnt, as a rule, makes acids (or acid anhydrides, the acids minus water but willing to drink themselves to acids proper); and so Lavoisier called the gas that helps to do all this "the acid maker," which meaning is safely hidden behind the parts of the Greek makeup, "oxy-gen." You will find out later that this claim of oxygen to make all acids, is not quite exact, but that there are acids which have no oxygen in them; but in every such case the acids have something which plays proxy for oxygen, so that in its broadest sense the name "oxygen," "acid maker," is not so bad for the "burn helper" in the air.

Repeat the Experiment Often

You must try this fundamental experiment of attacking the composition of the air over and over again and in every shape and method that your ingenuity can devise. Perhaps you can get some of the pure phosphorus to use, the kind that comes in yellow sticks and which must be kept under water to save it from burning up; or perhaps you can get a pinch of the so-called "red" phosphorus, a dark brownish-red powder, which is real phosphorus baked in a close vessel until it goes temporarily into this curious, sleepy form where it does not have to be kept under water to save it from burning; perhaps you can get some of this, to put in your little dish; but, whatever you do use, make it burn and make it take out all of the active oxygen from the air that it will, about one-fifth by volume at any rate. Usually you will get a larger apparent absorption, due to the aforesaid escape of some bubbles by heating.

You must keep your eye fixed on the several points: The good burning; the closing-in of the little saucer by the inverting of the jar; the absorption of part of the air in the jar and the testing of the remaining air; the testing of the water in the bottom of the jar. It all makes a part of the story of the composition of the air, but you will wonder how our friend limewater can help us out here. Well, that is an interesting question; and, in this chapter, we can only begin to show how limewater may have a great deal to do with the problems of burning.

Your thoughts will run somewhat as follows: It is all right to test such things as sulphur and phosphorus and match ends; but common coal is the thing which makes the bulk of fuel burnt, and we want to see what the air does to that, and how it does it.

The point which we are going to study is this: that coal burns first to carbon monoxide, CO, and this burns farther to carbon dioxide, your friend carbonic-acid gas, CO_2, or carbonic anhydride, the anhydride of true carbonic acid proper, H_2CO_3. Now the acids of phosphorus and sulphur and those strong-smelling things made from burning in the air, are readily absorbed by water; and they readily turn litmus red. But carbonic-acid gas is only feebly absorbed by water; it has not much taste and it does not act strongly on litmus; and so we are up against the question of trying to prove that when coal, or carbon, burns in the air, it does make its own form of acid, or acid anhydride, just as sulphur and phosphorus make theirs. You can begin to see how we are going to do this with the help of limewater; for you have already sucked the gases from glowing coal through some limewater, and you are fairly familiar with the acid properties of the gas from burning coal. But that special point will wait for another lesson; we want to get this point clinched, of the approximate amount of active "burn helper," oxygen, in the air.

There are one or two questions which may come up to your mind at this time.

One of them is this: What would happen if the air were pure oxygen? That is an interesting question, and you will make some experiments later with pure oxygen to show what would happen. But there are two forms to that question. One form is, what would happen if the nitrogen were taken out from the air and only the oxygen were left? That is one thing, but it would be quite another affair if the nitrogen were taken out from the air, and if its place were taken by so much more oxygen; that would be a condition of frightful possibilities, as you will see when you come to make pure oxygen.

One more question that I want you to think over between now and the reading of the next lesson is this: Why do you have to *light* a fire? Why doesn't it light itself? There is the fuel, there is the air, which you cannot see, but which you can feel, and it is waiting to take hold of your coal. But why does it wait until you kindle it, with all sorts of coaxing, from the match, through the shavings or paper, through the kindling wood, to the hard fuel; why all this preparation for what seems all ready to take place of and by itself? This question is worth some attention, the right answer will open your eyes to some things which no one can see, but which we must all believe to be true; it is the story of the chemical units, noted by those initial letters, and the groups into which those chemical units unite, groups which make up all kinds of material things which you see and feel every day. You are getting near the top of one of the foothills of science, and one of these days you will see the main range, and you can see all this from the window of your boiler room.

Credit for Low Pressure Turbines

In the February 2 number, page 241, L. Battu gives the credit of the conception and working out of the low-pressure turbine to Professor Rateau, mentioning J. W. Kirkland in a very complimentary way, but entirely ignoring W. L. R. Emmet, who at the International Electrical Congress, at St. Louis, in September, 1904, only a few months after Professor Rateau had presented at the Chicago meeting of the American Society of Mechanical Engineers the paper to which Mr. Battu refers, presented a paper containing the following, which shows that he had at that time a comprehensive idea of the advantages of the steam turbine for low-pressure work:

Portion of Paper Read in St. Louis, in September, 1904, at a Meeting of the International Electrical Congress

Since, as has been stated, the best steam turbines so far developed give degrees of economy about equal to those of the best steam engines, and since the turbine, as explained, works in a larger field of available energy, it may naturally be inferred that the steam engine within its own range of action is more efficient than the steam turbine, and this to a certain extent is true. This fact naturally suggests a combination which undoubtedly has a large field of application, namely, the use of low-pressure steam turbines taking exhaust steam from existing reciprocating engines. It is probable that such combinations will only be a phase of the steam-turbine development, since it is highly probable that efficiencies as high as the best steam-engine efficiencies will soon be attained by turbines under all ranges of pressure and that it will become desirable for many economic reasons to discard reciprocating engines altogether.

The most advantageous conditions for the combined use of reciprocating engines and steam turbines will be found in existing steam plants where reciprocating engines are used to operate electric generators separately or in parallel. In such plants low-pressure steam turbines can be installed and can be arranged to take steam directly from the exhaust pipe of engines without valves or governing mechanisms. The turbines would be designed to give a very high efficiency with highly expanded steam and a condensing plant should be installed adapted to the highest degree of vacua. The low-pressure valve stems and rod packings of the engines should be sealed with steam and other provisions should be made for the exclusion of air. The steam turbine should operate a generator adapted to connection in parallel with that driven by the engine.

A turbine designed for operation under these conditions would be an ideally simple affair and its maintenance and care would add little or nothing to the cost of station operation. There are many large stations in which the introduction of such turbines with proper condensing facilities would increase the output as much as 30 per cent., without any increase of the fuel consumption or change in the boiler plant. There are probably very few stations operated with reciprocating engines where the introduction in this manner of properly designed turbines would not increase the output as much as 20 per cent. In one case recently considered, 15 per cent. could be added to the output of the station without diminishing at all the work being done by the engines; that is, such an amount of work could be obtained with degrees of vacuum pressure entirely below those from which the engines are capable of deriving any benefit.

In such cases it would generally be desirable so to design the turbine that under full-load conditions it would take steam at a pressure of about 8 pounds absolute, corresponding approximately to the exhaust point in the low-pressure cylinder of the engine. The engine would then handle all the power which it could handle with maximum efficiency, and its own output would be only slightly reduced. The turbine would handle the power to which the engine was not well adapted. Under conditions of light load some economy might be effected by changing the cutoff conditions in the engine, but it would probably be better to leave all the conditions fixed and to allow the pressure on the turbine to vary as the load changed.

Such low-pressure turbines would occupy a small space and there are probably few existing engine plants in which room could not be provided for their installation. The cost of installing such turbines with complete condensing facilities should not exceed $60 per kilowatt of capacity added to the station. This in itself is a small expenditure for an additional plant, even if we do not consider the fact that the use of this additional plant does not call for any increase in fuel consumption or in steam-generating apparatus.

The following table shows the approximate increase of output which can be obtained by using a low-pressure turbine with good vacuum worked in series with a good Corliss engine over that which could be obtained from the engine alone when used with the best vacuum. The engine considered would consume with atmospheric exhaust 18 pounds per indicated horsepower, and with a vacuum of 27 inches or better 12.7 pounds per indicated horsepower. In the turbine an efficiency is assumed which is justified by actual experiments, and which can easily be obtained in a simple machine of this kind:

Pressure of Steam Between Engine and Turbine in Inches of Vacuum.	Per Cent. Gain Over Output of Engine When Worked with High Vacuum. The Turbine Exhausting to a Vacuum of 28.5 Inches.
0	26.1
4	26.5
8	26.8
12	26.3
16	25.3
20	23.6
24	20.0

These figures show an important possibility which should be realized in many existing plants; and they also illustrate forcibly the value of good vacuum in turbine work, since it shows the large amount of work available in these low-pressure ranges by the use of turbines.

One square foot of heating surface is needed in a boiler for every 200 cubic feet of space in a church or hall. In a dwelling house, every 500 cubic feet of space requires 1 square foot of heating surface. Radiators should have 1 square foot of superficial area to every 6 square feet of glass in windows and 1 square foot for every 80 cubic feet of space to be heated. One horsepower in a boiler is generally sufficient for 40,000 cubic feet.—*Exchange.*

Safety Valves

The Mechanical Engineers Devote an Evening to Their Discussion; Lift as a Factor of Valve Capacity, and as Experimentally Determined

The February meeting of the American Society of Mechanical Engineers was devoted to the consideration of safety valves. Frederic M. Whyte, General Mechanical Engineer of the New York Central lines, introduced the subject, speaking particularly of the safety valve as related to locomotive boilers:

FREDERIC M. WHYTE

The general practice in locomotive work has been to determine the size and number of valves to be used in an offhand way, and former practice has guided these determinations entirely. The capacity is indicated in an indifferent way expressed as a "size" referring to the diameter of something more or less certain, while the other dimension, the lift, which is necessary to give an indication of the capacity, is entirely ignored.

It will be comparatively easy to determine the capacities of valves, if the elaborate tests which have been already made, data from which will be presented in this discussion, have not already solved this part of the problem. More difficulty will be experienced in determining the quantity of steam to be discharged and the rate of release. Instead of indicating the capacity of the valve in a very rough way by the diameter of some opening, the method should be adopted of expressing the capacity in pounds of steam which the valve is capable of delivering at certain pressures. The capacity of the muffler need not be questioned except in extreme designs, but the indicated capacity should be that of the valve complete, with or without muffler according to the intended use of the valve.

In any kind of generating plant it ought to be quite sufficient if those immediately responsible for the quantity of steam produced know what is available. In stationary and marine work this is generally true and steam gages can be placed within view of those who should know what the pressure is at any time. Unfortunately, in locomotive work it has become perhaps desirable that others than those within view of the gage of the cab know something about the steam pressure, and inasmuch as the fireman is willing and sometimes anxious that they should know, he takes the only means at hand to inform them when he thinks that the results of his labors are good, and fires "against the pop" so that everybody within hearing or sight of the valve knows by the escaping steam that the fireman is doing his duty.

Assuming that such an indication of steaming conditions has grown to be a necessity, how can it be produced at the least expense? Two devices at least are available, the simmering valve, which will open slightly for two or three pounds about the normal maximum and then open full, just reversing this in seating, and the small pilot valve, which will open at two or three pounds pressure below the working valve. For the simmering valve, a seat must be used which will not cut under the wiredrawing action of the steam.

In locomotive practice it is not necessary that the valve capacity shall be equal to the maximum steaming capacity of the boilers, because the maximum steaming capacity is only at a time when steam is being used through the cylinders or blower to make the draft. Having fixed upon the per cent. of the generating capacity to be provided for in the valve, it will be necessary to determine the desirable unit capacity of the valves. Some States require that each locomotive boiler shall have at least two valves. Maintenance considerations indicate that these should be duplicates and therefore each has a capacity equal to one-half the required discharge capacity. If a number of boilers of different capacities are to be considered then the smaller ones will probably be provided with the same valves as the larger ones, for the purpose of duplication. There are some large boilers for which three valves may be necessary because the necessary capacity in two units might make the valves abnormally large for construction purposes. It is worth while also to consider whether undesirable results would come about from opening almost instantaneously an escape of steam from the boiler to the atmosphere. No suggestions are offered on this, but it is hoped that something bearing on the subject may be developed in the discussion.

L. D. LOVEKIN,

Chief Engineer of the New York Shipbuilding Company, said in part:

During 1903 I was asked to look into the rules and regulations as prescribed by the Board of Supervising Inspectors of the United States Steamboat Inspection Service concerning safety valves. This rule was established on grate surface without regard to the amount of coal burned thereon in a given time.

The rule as originally made served its purpose without trouble, but it must be remembered that this rule was made when such things as forced draft were almost unknown. Having in view the difference in the amount of coal now burned per square foot of grate surface, I prepared a new rule based on the well-known formula of Napier for the flow of steam through an orifice. The derivation of the formula is shown on page 473.

It will be noted that in preparing this work, the lift was based on 1/32 of the diameter of the valves, and while I consider this to be within good practical limits, I have found a number of safety-valve manufacturers who differ with me in regard to the lift. There is one thing certain, however, that whether the valve is restricted to 1/32 of its diameter or not, the net area of the opening should in my mind be at least equal to the tabled result indicated by the formula referred to.

I am not in favor of what might be termed an excessive lift of valve, such as one-fourth of the diameter, although some of our best recognized authorities in connection with the inspection of steamships still adhere to that list, the British Board of Trade being one of the foremost in this connection.

Unfortunately, when I presented the formula and table of safety valves to the board of supervising inspectors of steam vessels, they failed to state in their rules and regulations that the sizes of these valves were based upon the lift of the valve being equal to 1/32 of its diameter, and consequently left out a most important element. Under the rules of the board as they now exist in their printed forms it is quite possible to have a valve of the proper size in inches by said rules and yet be far below the actual requirements.

Having settled upon the proper diameter of a safety valve according to the formula, it will be evident that the clear area between the valve and its seat, due to having a lift equal to 1/32 of its diameter, is only about 1/11 of the area of the nominal diameter found by the formula. Therefore, it would seem that the inlet from the boiler to the safety valve should be equal in area only to the free area between the safety valve and its seat. This would reduce the opening in the boiler to about 1/11 of the area used at the present time.

Experiments in this line, however, have shown that a free entrance from the boiler to the safety valve is absolutely necessary to prevent chattering. Just exactly what relation this is I have not determined; in

fact, it would depend entirely on the length of the nozzle or pipe connecting the safety valve to the boiler. In most cases safety valves are bolted either directly to the boiler or to a casting bolted directly to the boiler and which forms a seat for both the safety and stop valves, so that there would be very little to gain in reducing the inlet nozzle to a safety valve.

While dealing with the inlet side of a safety valve, I think it might be proper to bring out a feature seldom if ever discussed in connection with safety valves, and that is the placing of safety valves upon the outlet end of dry pipes in boilers. These dry pipes, as is well known, usually consist of a pipe running along the upper part of a boiler and having slots cut into it so as to give an area equal to the full area of the pipe. In some cases which have come under my notice I have found the steam pressure within the boiler itself to be 200 pounds per square inch, while that of the outlet of the pipe was only 180 pounds, a drop of 20 pounds of pressure taking place due to wiredrawing the steam through the slots in the dry pipe. I have known of other cases where we have had 300 pounds of boiler pressure in connection with water-tube boilers and have purposely restricted the flow of steam through the dry pipe so as to cause a reduction in pressure of 50 pounds and thus obtain a slight degree of superheat. In this case, however, the valves were applied to the boiler drum and not to the dry pipe.

Some rules insist on the outlet area being equivalent to the full bore of the safety valve. This appears both inconsistent and unreasonable, for if we have only 1/11 of the area for the steam to pass through at the valve seat, we certainly do not require the full area of the steam to pass to the atmosphere. I think, however, that the area of the outlet from a safety valve should be equal to one-half the nominal area of the valve itself.

In the case of the United States cruiser "Tennessee," while on trial the main engines were stopped suddenly due to trouble with one of the connecting rods. All safety valves responded instantly and although the steam pressure went up 10 pounds above the popping point, no trouble was experienced as a result of this sudden stoppage, thus proving beyond doubt that a combined area of outlet pipe equal to one-half of the area of the safety valve, which is the way in which most of the United States battleships are equipped, is sufficient to prevent an excess of accumulation of pressure.

PHILIP G. DARLING,
Mechanical Engineer of Manning, Maxwell and Moore, submitted a paper on "Safety Valve Capacity," the purpose of which is to show an apparatus and method employed to determine safety-valve lifts, giving the results of tests made with this apparatus upon different valves; to analyze a few of the existing rules or statutes governing valve size and to propose a rule giving the results of a series of direct capacity tests upon which it is based; its application to special requirements, and finally to indicate its general bearing upon valve specifications.

Two factors in a safety valve geometrically determine the area of discharge and

DERIVATION OF THE UNITED STATES BOARD OF SUPERVISING INSPECTORS' RULE FOR AREAS OF SAFETY VALVES.

Napier's Rule for flow of steam through orifices:

$$\textit{Flow in pounds per second} = \frac{\textit{Absolute pressure} \times \textit{area}}{70}.$$

(This corroborated by Peabody's experiments.)

P = Absolute pressure = gage pressure + 15.
W = Pounds discharged per hour.
A = Area of valve opening or orifice.

Hence

$$W = \frac{P \times A}{70} \times 60^{\text{sec.}} \times 60^{\text{min.}} = \frac{360 \times A \times P}{7}.$$

For safety valve practice, cut this amount down 25 per cent., leaving 75 per cent.

Thus

$$W = 0.75 \times \frac{360}{7} \times A \times P = \frac{270 \times A \times P}{7}.$$

Restrict the lift of valve to $\frac{1}{32}$ of its diameter $= \frac{d}{32}$,

then

$$A\ \frac{d}{32} \times \pi \times d = \textit{lift} \times \textit{circumference} = \frac{\pi \times d^2}{32}.$$

Substituting this value for A = area of orifices

$$W = \frac{270}{7} \times P \times \frac{\pi d^2}{32}.$$

In a valve of diameter d the area $=$

$$\frac{\pi d^2}{4} = a.$$

To get W in terms of area of valve, substitute for d^2 its value in terms of a,

$$d^2 = \frac{4a}{\pi}.$$

$$W = \frac{270}{7} \times P \times \frac{\pi}{32} \times \frac{4a}{\pi} = 4.821 \times P\,a.$$

In safety valve practice this will represent the pounds of steam that must escape per hour, which must be equal to the pounds of water that the boiler can evaporate per hour.

To reduce this to a working basis, consider these quantities per square foot of grate surface per hour.

W = Pounds of water evaporated per square foot of grate surface per hour.

P = Absolute pressure per square inch.

A = Area of safety valve per square foot of grate surface.

Hence

$$W = 4.821 \times P \times a, \text{ and } a = 0.2074 \times \frac{W}{P}.$$

From which a table of areas required per square foot of grate surface may be found by assuming the different values of W and P.

hence the relieving capacity; the diameter of the inlet opening at the seat and hights upon the chart are carefully calibrated so that the record may be accurately measured to thousandths of an inch.

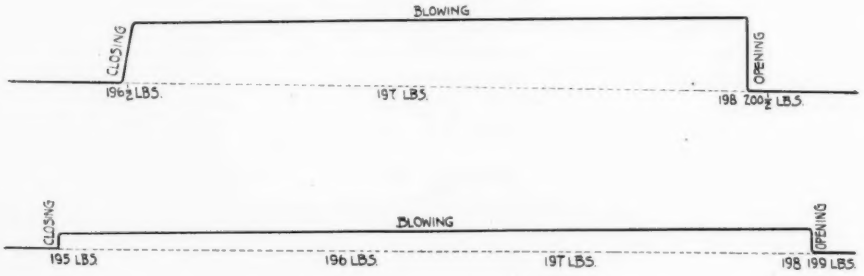


FIG. 1. TYPICAL HIGH- AND LOW-LIFT SAFETY-VALVE DIAGRAMS

In testing, the motor driving the paper drum is started and the pressure in the boiler raised. The valve being mounted directly upon the boiler, then pops, blows down and closes under the exact conditions of service, the pencil recording on the chart the history of its action.

With this apparatus, investigations and tests were started upon seven different makes of 4-inch stationary safety valve, and these tests were followed with similar ones upon nine makes of muffler locomotive valve, six of which were 3½-inch,

the valve lift. The former is the nominal valve size, the latter is the amount the valve disk lifts vertically from the seat when in action. In calculating the sizes of valves to be placed on boilers, rules which do not include a term for this valve lift, or an equivalent, such as a term for the *effective* area of discharge, assume in their derivation a lift for each size of valve. Nearly all existing rules and formulas are of this kind which rate all valves of a given nominal size as of the same capacity.

To find what lifts valves of standard make actually have in practice, and thus test the truth or error of this assumption that they are approximately the same for valves of the same size, an apparatus has been devised and tests upon different makes of valves conducted. With this apparatus not only can the valve lift be read at any moment to one-thousandth of an inch, but an exact permanent record of the lift during the blowing of the valve is obtained somewhat similar to a steam-engine indicator diagram in appearance and of a quite similar use and value in analyzing the action of the valve. See Fig. 1.

As appears in Figs. 2 and 3, the valve under test is mounted upon the boiler in the regular manner, and a small rod is tapped into the top end of its spindle, which rod connects the lifting parts of the valve directly with a circular micrometer gage, the reading hand of which indicates the lift upon a large circular scale or dial. The rod through this gage case is solid, maintaining a direct connection to the pencil movement of the recording gage above. This is a modified Edson recording gage with a multiplication in the pencil movement of about 8 to 1 and, with the chart drum driven by an electric motor, giving a horizontal time element to the record. The steam pressures are noted and read from a large test gage graduated in pounds per square inch, and an electric-spark device makes it possible to spot the chart at any moment, which is done as the different even pound pressures during the blowing of the valve are reached. The actual lift equivalents of the pencil

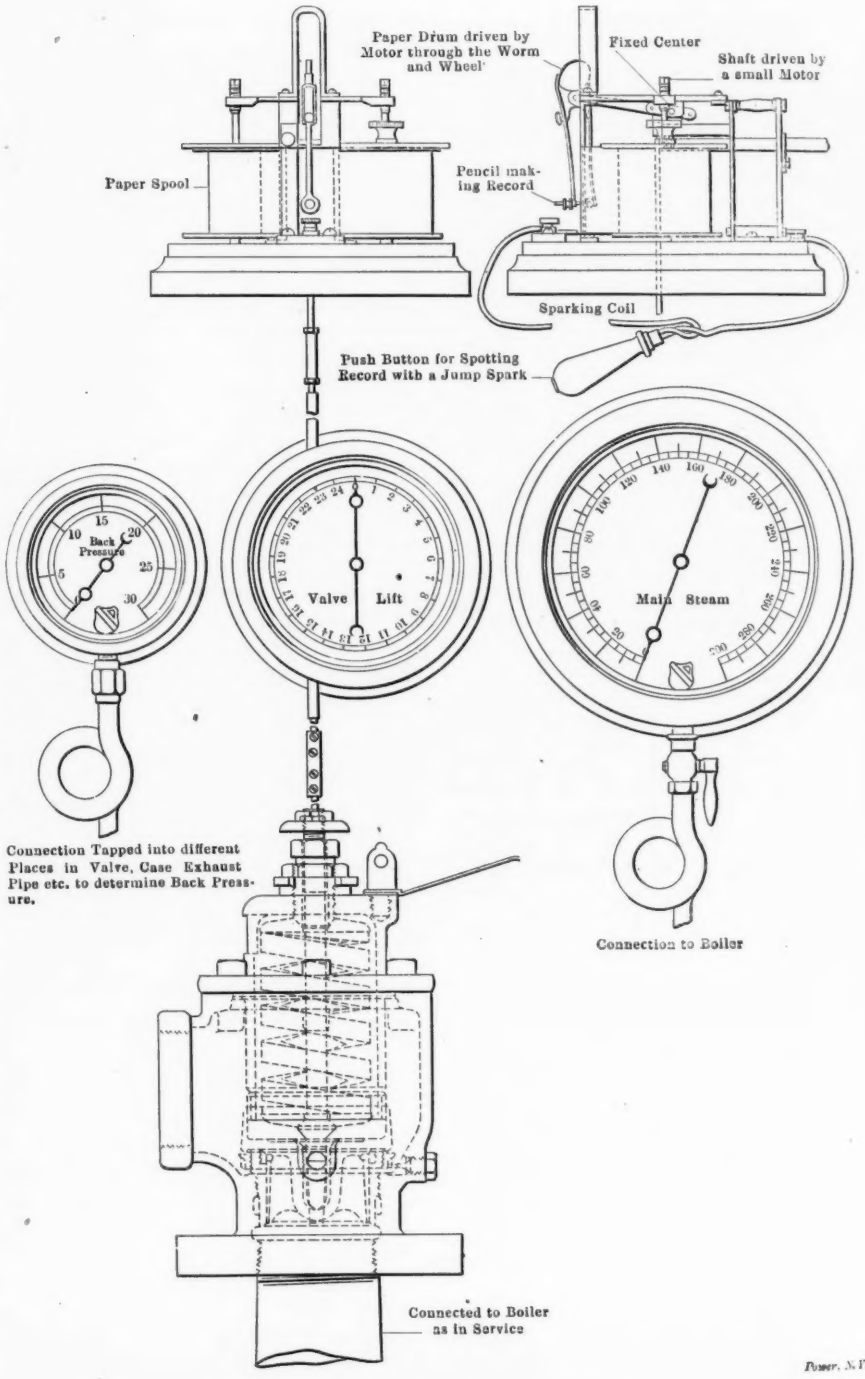

Paper Drum driven by Motor through the Worm and Wheel
Fixed Center
Shaft driven by a small Motor
Paper Spool
Pencil making Record
Sparking Coil
Push Button for Spotting Record with a Jump Spark
Back Pressure
Valve Lift
Main Steam
Connection Tapped into different Places in Valve, Case Exhaust Pipe etc. to determine Back Pressure.
Connection to Boiler
Connected to Boiler as in Service
Power, N.Y.

FIG. 2. OUTLINE DRAWING OF THE SAFETY-VALVE TESTING APPARATUS

all of the valves being designed for and tested at 200 pounds. The stationary-valve tests were made upon a 94-horse-power water-tube boiler made by the Babcock & Wilcox Company. The locomotive-valve tests were made upon locomotive No. 800 of the Illinois Central railroad, the valve being mounted directly upon the top of the main steam dome. This locomotive is a consolidation type, having 50 square feet of grate area and 2953 square feet of heating surface. Although a great amount of additional experimenting has been done, only the results of the foregoing will be quoted in this paper. These lift records show (with the exception of a small preliminary simmer which some of the valves have) an abrupt opening to full lift and an almost equally abrupt closing when a certain lower lift is reached. Both the opening and closing lifts are significant of the action of the valves.

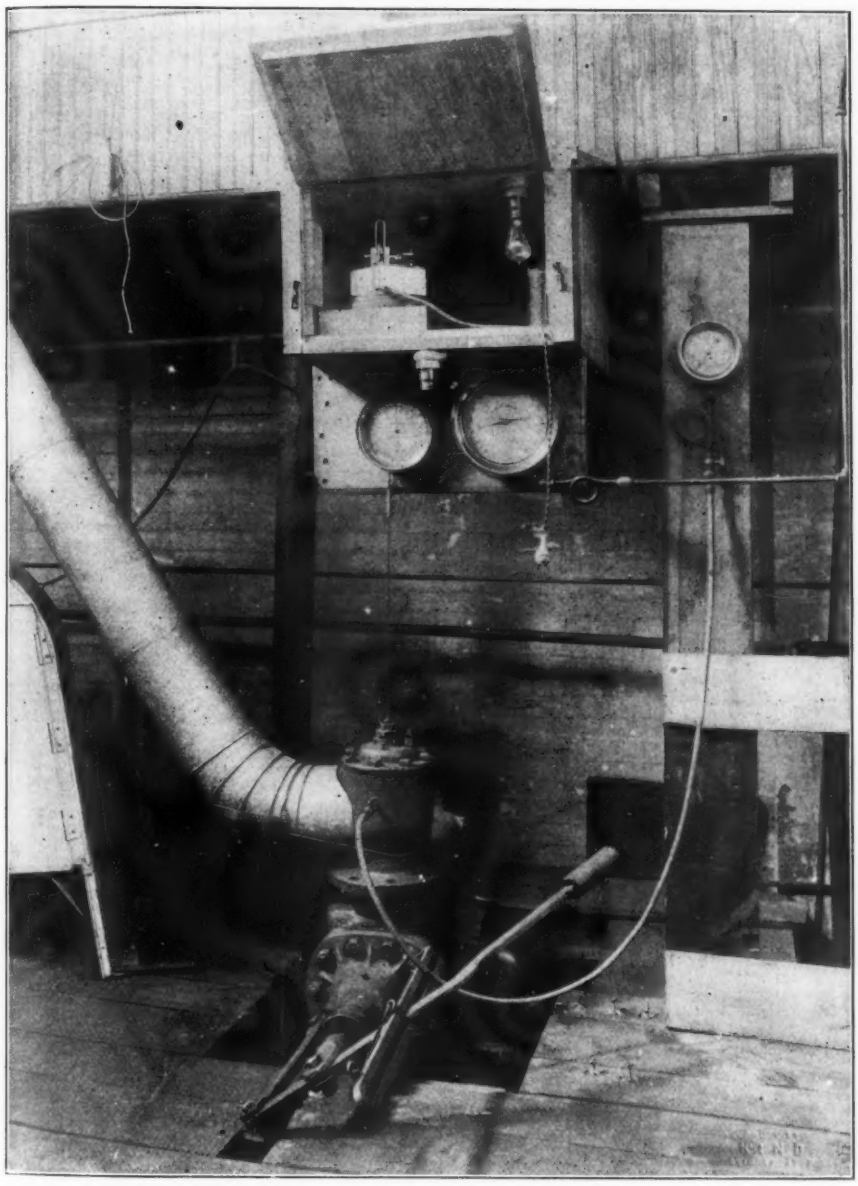


FIG. 3. PHOTOGRAPH OF THE APPARATUS

The results of the 4-inch iron-body stationary valve tests summarized are as follows: Of the seven valves the average lift at opening was 0.079-inch and at closing 0.044-inch, or, excluding the valve with the highest lifts, the averages were 0.07-inch at opening and 0.037-inch at closing. The valve with the lowest lifts had 0.031-inch at opening and 0.017-inch at closing, while that with the highest had 0.137-inch and 0.088-inch. Expressing the opening lifts as percentages of the highest, the lowest had 31.4 per cent., the next larger 40.8 per cent., and the next 46.6 per cent. Of the six 3½-inch muffler locomotive valves the summarized lifts are as follows: Average of the six valves, 0.074-inch at opening and 0.043-inch at closing. Average, excluding the highest, 0.061-inch at opening and 0.031-inch at closing. The lowest lift valve had 0.04-inch opening and 0.023-inch closing; the highest 0.140-inch opening and 0.102-inch closing. As percentages of the highest, the lowest lift valve was 36.4 per cent., the next larger 39.8 per cent., and the next 46.4 per cent.

The great variation—300 per cent.—in the lifts of these standard valves of the same size is startling and its real significance is apparent when it is realized that under existing official safety-valve rules these valves, some of them with less than one-third the lift and capacity of others receive the *same* rating and are listed as of equal relieving value.

[After explaining the rule of the board of supervising inspectors, the derivation of which is explained in Mr. Lovekin's remarks, Mr. Darling says]:

In the valves to which this rule is applied the following lifts are assumed to exist: 1-inch valve, 0.03; 2-inch valve, 0.06-inch; 3-inch valve, 0.09-inch; 4-inch valve, 0.13-inch; 5-inch valve, 0.15-inch; 6-inch valve, 0.19-inch.

Referring back to the valve lifts found by test, it is seen that the highest lift agrees very closely with the lift assumed in the rule and if the valve lifts of the different designs were more uniformly of this value or if the rule expressly stipulated either that the lift of 1/32 of the valve diameter actually obtains in valves qualifying under it or that an equivalent discharge area be obtained by the use of larger valves, the rule would apply satisfactorily to that size of valve. However, the lowest-lift valve actually has but ¼, the next larger less than ½ and the average lift of all but the highest-lift valve, which average is 0.07-inch, is but 56 per cent. of the lift assumed in the rule for these 4-inch valves.

Massachusetts Rule of 1909:

$$A = \frac{W \times 70}{P} \times 11,$$

where

A = Total area of safety valve or valves in square inches,

W = Pounds of water evaporation per square foot of grate surface per second,

P = Boiler pressure (absolute).

One of the most recently issued rules is that contained in the pamphlet of the new Massachusetts Board of Boiler Rules, dated March 24, 1908. This rule is merely the United States rule given herewith with a 3.2 per cent. larger constant and therefore requiring that amount larger valve. The evaporation term is expressed in pounds per second instead of per hour, and two constants are gi en instead of one, but when reduced to the form of the United States rule it gives

$$A = 0.214 \times \frac{W}{P}.$$

Figuring this back, as was done with the United States rule, and taking the 75 per cent. of the flat seat area as there

done, shows that this rule assumes a valve lift of 1/33 of the valve diameter instead of 1/32 of the United States rule. This changing of the assumed lift from 1/32 to 1/33 of the valve diameter being the only difference between the two rules, the inadequacy of the United States rule just referred to applies to this more recent rule of the Massachusetts Board.

Philadelphia Rule:

$$A = \frac{22.5\,G}{P \times 8.62},$$

where

A = Area of safety valve in square inches per square foot of grate,
G = Grate area in square feet,
P = Boiler pressure (gage).

The Philadelphia rule now in use came from France in 1868, being the official rule there at that time, and was adopted and recommended to the City of Philadelphia by a specially appointed committee of the Franklin Institute; although this committee frankly acknowledged in its report that it "had not found the reasoning upon which the rule had been based." The area A of this rule is the effective valve opening, or, as stated in the Philadelphia ordinance of July 13, 1868, "the least sectional area for the discharge of steam." Consequently, if this rule were to be applied as its derivation by the French requires, the lift of the valve must be known and considered whenever it is used. However, the example of its application given in the ordinance, as well as that given in the original report of the Franklin Institute committee which recommended it, show the area A applied to the nominal valve opening. In the light of its derivation this method of using it takes as the effective discharge area the valve opening itself, the error of which is very great. Such use, as specifically stated in the report of the committee referred to, assumes a valve lift at least ¼ of the valve diameter, i.e., the practically impossible lift of 1-inch in a 4-inch valve.

The principal defect of these rules in the light of the preceding tests is that they assume that valves of the same nominal size have the same capacity and they rate them the same without distinction in spite of the fact that *in actual practice some have but one-third of the capacity of the others.* There are other defects as have been shown, such as varying the assumed lift as the valve diameter, while in reality with a given design the lifts are more nearly the same in the different sizes, not varying nearly as rapidly as the diameters. And further than this, the actual lifts assumed for the larger valves are nearly double the actual average obtained in practice.

The elements of a better rule for determining safety-valve size exist in Napier's formula for the flow of steam, combined with the actual discharge area of the valve as determined by its lift. In "Steam Boilers," by Peabody and Miller, this method of determining the discharge of a safety valve is used. The uncertainty of the coefficient of flow, that is, of the constant to be used in Napier's formula when applied to the irregular steam discharge passages of safety valves has probably been largely responsible for the fact that this method of obtaining valve capacities

SAFETY-VALVE CAPACITY TESTS.

RUN AT THE STIRLING WORKS OF THE BABCOCK AND WILCOX CO., BARBERTON, OHIO, NOV. 30, TO DEC. 23, 1908.

Test Number.	Duration of Test.	Size and Type of Valve.	Adjustment Remarks.	Valve Lift.	Pressure.	Superheat.	Discharge per Hour.	Discharge Area. Note No. 1.	Remarks.
	Hours.			Inch.	Lb. per Sq.In.	Deg. F.	Lb. of Steam.	Sq.In.	
6	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.0695	151.7	43.6	5,120	0.6226	No back pressure.
7	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.139	145.4	45.1	8,600	1.255	Back pressure 2 lb.
8	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.180	135.7	49.2	11,020	1.704	Back pres. 3 lb., max. pres.; lift > depth of seat.
9	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.1045	149.4	41.9	7,290	0.9400	Back pressure 1 lb.
10	2½	3½″ locomotive. Form B	Regular Adj., without muffler	0.140	146.7	39.0	8,685	1.109	Tests 10-12 inclusive with an open locomotive valve.
11	3	3½″ locomotive. Form B	Regular Adj., without muffler	0.070	152.5	38.0	4,670	0.5493	
12	3	3½″ locomotive. Form B	Regular Adj., without muffler	0.105	150.3	41.2	6,780	0.8280	
13	3	3½″ locomotive. Form B	Regular Adj., with muffler	0.1395	146.3	38.1	8,400	1.106	Muffler valve in this following locomotive tests.
14	2	3½″ locomotive. Form B	Regular Adj., with muffler	0.140	52.2	51.3	3,620	1.109	Test at low steam pressure.
15	2½	Same, except with lipped feather	Regular Adj., with muffler	0.140	146.4	39.0	8,600	1.109	Different type of valve disk.
16	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.140	138.5	42.3	8,770	1.265	No back pressure, repetition of test No. 7.
17	3	4″ R.F. iron stationary	Adj. ring one turn. 1/16″ above Reg. Posi.	0.140	142.0	50.1	8,900	1.265	Back pressure 3 lb., adj. ring position changed.
18	2	1½″ locomotive. Form B	Regular Adj., with muffler	0.107	140.8	23.0	2,515	0.4272	Tests 18-21 inclusive. Unsatisfactory as the valve was too small for the boiler used.
19	1	1½″ locomotive. Form B	Regular Adj., with muffler	0.060	151.2	None	1,550	0.2038	
20	2½	1½″ locomotive. Form B	Regular Adj., with muffler	0.075	146.3	None	2,025	0.2560	
21	2½	1½″ locomotive. Form B	Regular Adj., with muffler	0.075	147.7	None	1,975	0.2560	
22	1½	3½″ R.F. iron stationary	Regular Adj., Exh. piped	0.070	146.8	42.6	4,320	0.5493	No back pressure.
23	3	3½″ R.F. iron stationary	Regular Adj., Exh. piped	0.140	139.9	43.6	8,360	1.136	No back pres., lift > depth of seat.
24	3	3½″ R.F. iron stationary	Regular Adj., Exh. piped	0.105	141.6	48.7	6,300	0.8280	Tests 24-27 inclusive. No back pressure.
25	3	3″ R.F. iron stationary	Regular Adj., Exh. piped	0.130	140.1	48.4	6,370	0.8846	
26	3	3″ R.F. iron stationary	Regular Adj., Exh. piped	0.100	142.8	45.6	5,160	0.6770	
27	2	3″ R.F. iron stationary	Regular Adj., Exh. piped	0.070	142.4	29.5	3,705	0.4716	
28	3	3″ locomotive. Form B	Regular Adj., with muffler	0.130	138.4	48.7	7,060	0.8846	
29	3	3″ locomotive. Form B	Regular Adj., with muffler	0.090	139.3	43.9	4,950	0.6034	

NOTE No. 1.—The valves all having 45° bevel seats, these areas are obtained from formula: $a = 2.22 \times D \times l + 1.11 \times l^2$ except where as in tests Nos. 8, 18, 23, 25, the valve lift is greater than the depth of the valve seat, where the following formula is used: $a = 2.22 \times D \times d + 1.11 \times d^2 + \pi \times D \times (l - d)$. a = discharge area (sq.in.). D = valve dia. (in.). l = valve lift (in.). d = depth of valve seat (in.).

NOTE No. 2.—The four wings of the valve feather or disk probably reduce the flow slightly, but as these are cut away at the seat a definite correction of the exit areas for them is impossible. Further, the formula constants are desired for the valves as made.

has not been more generally used. To determine what this constant or coefficient of flow is and how it is affected by variations in valve design and adjustment, an extended series of tests have recently been conducted at the Stirling department of the Babcock & Wilcox Company, at Barberton, Ohio.

A 373-horsepower class K No. 20 Stirling boiler, fired with a Stirling chain grate, with a total grate area of 101 square feet, was used. This boiler contained a U-type of superheater designed for a superheat of 50 degrees Fahrenheit.

The valves tested consisted of a 3-, 3½- and a 4-inch iron stationary valve, and a 1½-, 3- and 3½-inch locomotive valve, the latter with and without mufflers. These six valves were all previously tested and adjusted on steam. Without changing the position of the valve disk and ring the springs of these valves were then removed and solid spindles, threaded (with a 10-pitch thread), inserted through the valve casing above. Upon the top ends of these spindles were placed handwheels graduated with 100 divisions, shown in Fig. 4 as applied to the locomotive valves, the spindle and graduated wheel being similar to that used with the stationary valves. By this means the valve lift to thousandths of an inch was definitely set for each test and the necessity for constant valve-lift readings with that source of error eliminated. In all 29 tests were run, fifteen were 3 hours long, four 2½ hours, three 2 hours and seven of shorter duration.

Tests numbered 1 to 5 were preliminary runs of but one hour or less apiece, and the records of them are thus omitted in the accompanying table which gives the lifts, discharge areas, average pressure and superheat, and the steam discharge in pounds per hour of each of the other tests. The discharge areas have been figured for 45-degree seats from the formula

$$a = 2.22 \times d \times L + 1.11 \times L^2,$$

where a equals the effective area in square inches, d the valve diameter in inches and L the valve lift in inches.

In tests 8 and 23, where the width of valve seat was 0.225-inch and 0.185-inch, respectively, and the valve was thus slightly above the depth of the valve seat, the area was figured for this condition.

As previously stated the application of these results is in fixing a constant for the flow of Napier's formula as applied to safety valves. This formula (given in the derivation of the board of supervising inspectors' rule) may be stated as

$$E = C \times a \times P,$$

in which E equals the pounds of steam discharged per hour and C is a constant; E, a and P being given for the tests, C is directly obtainable.

Figuring and plotting the values of this constant indicates the following conclusions:

(1) Increasing or altering the steam pressure from approximately 50 to 150 pounds per square inch (tests 14 and 10) does not affect the constant, this merely checking the applicability of Napier's formula in that respect.

(2) Radically changing the shape of the valve disk outside of the seat at the huddling or throttling chamber, so-called, does not affect the constant or discharge. In test No. 15 the valve had a downward projecting lip, resulting in deflecting the steam flow through nearly 90 degrees, yet the discharge was practically the same as in tests 10 and 14, where the lip was cut entirely away, as in Fig. 4, giving a comparatively unobstructed flow to the discharging steam.

(3) Moving the valve-adjusting ring

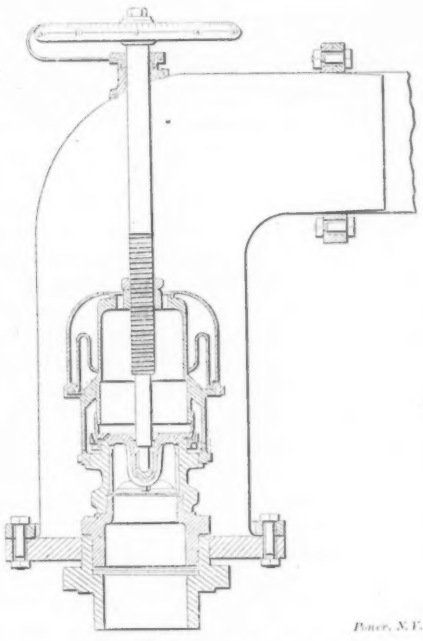


FIG. 4. VALVE SECTION

through much more than its complete-adjustment range does not affect the constant or discharge (tests 16 and 17).

(4) The addition of the muffler to a locomotive valve does not materially alter the constant or discharge. There is but 2 per cent. difference between tests 10 and 13.

(5) Disregarding the rather unsatisfactory 1½-inch and 3-inch locomotive-valve tests, the different sizes of valves tested show a variation in the constant when plotted to given lifts of about 4 per cent.

(6) There is a slight uniform decrease of the constant when increasing the valve lifts.

The variations indicated in the last two conditions are not large enough, however, materially to impair the value of a single constant obtained by averaging the constants of all the twenty-four tests given. The selection of such a constant is obviously in accord with the other four conditions mentioned. This average constant is 47.5, giving as the formula

$$E = 47.5 \times a \times P.$$

Its theoretical value for the standard orifice of Napier's formula is 51.4, of which the above is 92½ per cent.

To make this formula more generally serviceable, it should be expressed in terms of the valve diameter and lift, and can be still farther simplified in its application by expressing the term E (steam discharged or boiler evaporation per hour) in terms of the boiler-heating surface or grate area. For the almost universal 45-degree seat the effective discharge area is, with a slight approximation,

$$L \times \textit{sine}\ 45 \times \pi \times D,$$

in which L equals the valve lift vertically in inches and D the valve diameter in inches. Substituting this in the foregoing formula gives

$$E = 47.5 \times L \times \textit{sine}\ 45 \times \pi \times D \times P,$$

or

$$E = 105.5 \times L \times D \times P.$$

The slight mathematical approximation referred to consists in multiplying the $L \times \textit{sine}\ 45$ by $\pi \times D$, instead of by the exact value $\pi \times D$ plus ½ L. To find directly the effect of this approximation upon the constant, the values for E, L, D and P from the tests have been substituted into the formula and the average constant redetermined, which is 108.1. The average lift of all the tests is 0.111-inch. Plotting the constants obtained from the formula in each test, as ordinates, to valve lifts, as absissae; obtaining thus the slight inclination referred to in condition (6), and plotting a line with this inclination through the obtained average constant, 108.1, taken at the 0.111 average lift, gives a line which at a maximum lift of, say, 0.14-inch gives a constant of just 105. At lower lifts this is slightly larger. Therefore, 105 would seem to be the conservative figure to adopt as a constant in this formula for general use, giving

$$E = 105 \times L \times D \times P.$$

This transposed for D gives:

$$D = 0.0095 \times \frac{E}{L \times P}.$$

Note that the nominal valve area does not enter into the use of this formula and that if a value of 12, for instance, is obtained for D it would call for two 6-inch or three 4-inch valves. For flat seats these constants become 149 and 0.0067, respectively.

The fact that these tests were run with some superheat (an average of 37.2 degrees Fahrenheit), while the majority of valves in use are used with saturated steam, would, if any material difference

exists, place these constants on the safe side. The capacities of the stationary and locomotive valves, the lift-test results of which are summarized in the foregoing, have been figured from this formula, taking the valve lifts at opening and in pounds of steam per hour, and are as follows:

Of the seven 4-inch iron-body stationary valves, the average capacity at 200 pounds pressure is 7370 pounds per hour, the smallest capacity valve (figured for a flat seat) has a capacity of 3960 pounds, the largest 12,400 pounds; and of the six 3½-inch muffler locomotive valves at 200 pounds pressure, the average capacity is 6060 pounds per hour, the smallest 4020 pounds, the largest 11,050 pounds.

To make the use of the rule more direct where the evaporation of the boiler is only indirectly known it may be expressed in terms of the boiler-heating surface or grate area. This modification consists merely in substituting for the term E (pounds of total evaporation per hour) a term H (square feet of total heating surface) multiplied by pounds of water per square foot of heating surface per hour which the boiler will evaporate. Evidently the value of these modified forms of the formula depends upon the proper selection of average boiler evaporation figures for different types of boiler and also upon the possibility of so grouping these boiler types that average figures can be thus selected. This modified form of the formula is

$$D = C \times \frac{H}{L \times P},$$

in which H equals the total boiler heating surface in square feet and C is a constant.

Values of the constant for different types of boiler and service have been selected. These constants are susceptible, of course, to endless discussion among manufacturers and it is undoubtedly more satisfactory where any question arises to use the form containing the term E itself. Nevertheless the form containing the term H is more direct in its application and it is believed that the values given in the following for the constant will prove serviceable. In applying the formula in this form rather than the original one containing the evaporation term E, it should be remembered that these constants are based upon average proportions and, therefore, should not be used for boilers in which any abnormal proportions or relations between grate area, heating surface, etc., exist.

For cylindrical multitubular, vertical and water-tube stationary boilers a constant of 0.068 is suggested. This is based upon an average evaporation of 3½ pounds of water per square foot of heating surface per hour, with an overload capacity of 100 per cent., giving 7 pounds per square foot of heating surface, the figure used in obtaining the constant.

For water-tube marine and Scotch marine boilers, the suggested constant is 0.095. This is based upon an overload or maximum evaporation of 10 pounds of water per square foot of heating surface per hour.

For locomotive valves the constant is 0.055, determined experimentally as explained in what follows: In locomotive practice there are special conditions to be considered which separate it from regular stationary and marine work. In the first place the maximum evaporation of a locomotive is only possible with the maximum draft obtained when the cylinders are exhausting up the stack, at which time the throttle is necessarily open. The throttle being open is drawing some of the steam and, therefore, the safety valves on a locomotive can never receive the full maximum evaporation of the boiler. Just what per cent. of this maximum evaporation the valve must be able to relieve under the most severe conditions can only be determined experimentally. Evidently the severest conditions obtain when an engineman, after a long, hard, uphill haul, with a full glass of water and full pressure, reaches the top of the hill and suddenly shuts off his throttle and injectors. The work on the hill has got the engine steaming to its maximum and the sudden closing of throttle and injectors forces all the steam through the safety valves. Of course, the minute the throttle is closed the steaming quickly falls off and it is at just that moment that the severest test upon the valves comes.

A large number of service tests have been conducted to determine this constant. The size of the valves upon a locomotive has been increased or decreased until one valve would just handle the maximum steam generation and, the locomotive heating surface being known, the formula was figured back to obtain the constant. Other special conditions were considered, such as the liability in locomotive practice to a not infrequent occurrence of the most severe conditions; the exceptionally severe service which locomotive safety valves receive; and the advisability on locomotives to provide a substantial excess valve capacity.

As to the method of applying the proposed safety-valve capacity rule in practice, manufacturers could be asked to specify the capacities of their valves, stamping them upon them as the opening and closing pressures are now done. This would necessitate no extra work, only the time required in the stamping, because for valves of the same size and design giving practically the same lift this would have to be determined but once, which of itself is but a moment's work with the small portable lift gage now available. The specifying of safety valves by a designing engineer could then be as definite a problem as is that of other pieces of apparatus. Whatever views are held, as to the advantages of high or low lifts, there can be no question, it would seem, as to the advantage of knowing what this lift actually is, as would be shown in this specifying by manufacturers of the capacities of their valves. Further, as to the feasibility of adopting such a rule (which incorporates the valve lift) in statutes governing valve sizes, this would involve the granting and obtaining by manufacturers of a legal rating for valve designs based upon their demonstrated lifts.

Wrought Pipe

By H. E. Schuler

At one time I worked in the pipe shop of a large manufacturing concern and became more or less familiar with the mistakes made by engineers and others in ordering pipe.

Standard pipe is always measured on the inside (that is 2-inch pipe measures 2 inches inside diameter, etc.) up to and including 12-inch pipe. Above 12-inch, pipe is always measured on the outside and is called "O.D.," or outside-diameter pipe. Extra-strong and double-extra-strong pipe are very nearly of the same outside diameter as standard pipe, the extra thickness being on the inside, thereby decreasing the inside diameter or area of the pipe. For this reason no special die is required to thread them.

In ordering pipe always remember that standard pipe comes threaded, with a coupling on one end, up to and including 12-inch pipe, and above this size, or all "O.D." pipe, the pipe comes with plain ends and an extra charge is made for threads and couplings. The thickness of "O.D." pipe must be specified if you wish it threaded, as it is impractical to thread this pipe when less than 5/16 inch in thickness. Extra-strong and double-extra-strong pipe also come with plain ends and an extra charge is made for threads and couplings.

A great many engineers in ordering pipe simply specify a certain number of feet of wrought pipe of certain size and labor under the delusion that they are getting wrought-iron pipe when they are really getting wrought-steel pipe.

If you wish wrought-iron pipe you must specify: "This pipe must be strictly wrought-iron." Wrought-iron pipe costs a little more than wrought-steel pipe and the bursting pressure is considerably less.

A great many engineers claim that wrought-iron pipe is more durable than and not as susceptible to corrosion as wrought-steel pipe and are willing to pay a little more for it. Of course, the safe working pressure of any pipe varies with the inside diameter and the thickness; also

the weld, which is always an uncertain factor. From ⅛- to 3-inch pipe can be secured in the butt weld and from 1½-inch up in the lap weld.

Pipe from ⅛- to 3-inch is tested at from 600 to 1000 pounds, and 3-inch to 15-inch at from 500 to 1000 pounds, before leaving the factory. Several lengths of 8- and 10-inch standard pipe were tested and burst at from 1800 to 3200 pounds pressure, but of course there are factors, such as expansion, joints, strains due to improperly hanging threads, etc., which should be taken into consideration when installing pipe. Pieces of pipe 12 inches or under in length are called nipples and are measured from end to end the same as pipe and not between the threads, as thought by some people.

Some of the defects to look for in wrought pipe are poor threads, brittleness, defective welds, flat places and hard spots. The most common complaint is of poor threads, and nine times in ten this complaint would not be registered if a little judgment were used by the engineer or steamfitter. Quite often the end of pipe is jammed against something which pushes the first thread back against the second, making it impossible to start the fitting on the pipe. A few minutes' work with the hammer and cold chisel repairs this and the fitting goes on all right. Sometimes a thread or two are slightly broken, but if one or two threads are completely stripped from the pipe it will not spoil a properly made joint.

When the pipe breaks off in layers just ahead of or between the cutting points of the dies it is defective and should be returned. There are several good dies in the market for threading pipe, also several poor ones, and some judgment should be used in purchasing a set. Personally I always buy an adjustable die so that in cutting pipe 1¼-inch or over I can take two cuts, thereby decreasing the labor. Adjustable dies are also very handy in cutting special threads for any purpose.

Dr. Frederick W. Taylor, past-president of the American Society of Mechanical Engineers, gave an address before the College of Engineering of the University of Illinois, on Thursday, February 18, along general engineering lines supplemented by anecdotes from the early part of the careers of successful engineers.

A movement has been set on foot by the English Ceramic Society for a conference of representatives of the various technical institutes and societies, to consider ways and means of arranging for the "grading" and standardizing, as far as possible, of the refractory materials, such as fireclay, magnesite, etc., used in the construction of furnaces, kilns and ovens.

Square Plaited Ropes

Square plaited ropes, which are, we believe, of German origin, are much more extensively used abroad than in this country. Quite recently, however, Veithardt & Co., Limited, of 26 and 27 Bush lane, Cannon street, E. C., has taken up the agency here and has already supplied several factories with this type of rope. From what we can gather it appears to

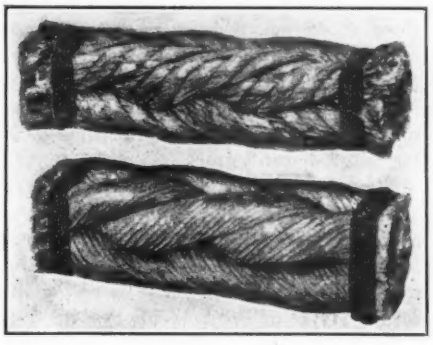


FIG. 1. SQUARE ROPE

give excellent results and to be very durable. The accompanying engraving shows two forms of this rope. They are designed specially for driving and not for cable work, as it is recognized that they will not turn, and are, therefore, unsuitable for the latter use. The severest work to which any form of rope may be submitted is probably the driving of

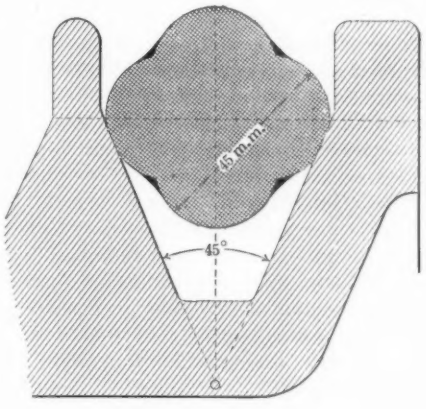


FIG. 2. SQUARE ROPE IN GROOVE

rolling mills. Yet many such mills are now being satisfactorily driven with square plaited ropes. For this purpose a cabled construction is used, its form being shown in the top view of Fig. 1. Each strand is twisted before use into an independent rope, and each strand comprises several threads. The lower view of Fig. 1 shows the plaiting of an ordinary standard open-construction rope. The ropes are made of hemp or cotton, and the firm guarantees a hemp rope, although cheaper, to outlast a cotton rope. No special pulleys are required, as the rope fits into an ordinary groove in the manner shown in Fig. 2. The ropes each comprise eight strands; two sets of four strands each are, so to speak, opposed to each other, by which means it is claimed that the rope follows an even and uniform course, whilst it is free from any tendency to twist or turn. High pliability is another advantage claimed for this form of rope, and pulleys of only eighteen to twenty times the section of the rope can be used, which is small compared with what is required for round ropes. We were told that special attention is paid to the treatment of the rope while under construction to take as much of the stretch out of it as possible. Each strand is stretched before use, and the special manner of plaiting permits of stretching the ropes to the maximum limit. To render them waterproof they are impregnated with a special solution, no tar being used.

With regard to the properties of the square plaited rope, we were informed that the 1¾-inch size will replace and give the same power as a 2-inch round rope and that it is from 10 to 15 per cent. lighter than the round rope which it displaces. But the square ropes which have been impregnated as a protection against the influence of the weather are naturally heavier than those which have not been so treated. The following table by the maker gives some interesting data relating to the square ropes which will enable a comparison to be made with the better known round rope drives:

Square Plaited Ropes.				
Thickness.	Cross Section.	Approximate Weight.	Smallest Diameter of Pulley.	Approximate Thickness of Corresponding Round Rope.
mm.	sq. in. (approx.)	lb.	in.	in.
25	1	1.21	9.4	1.1
30	1¼	1.98	11.25	1.38
35	1½	2.42	17.5	1.575
40	2¼	3.19	20.0	1.76
45	3¼	3.85	22.5	1.97
50	3¾	4.73	27.5	2.2
55	4¼	5.94	35.0	2.42

The load is generally assumed to be from 85 to 115 pounds per square inch of section; 100 being the general practice with these ropes. The square plaited ropes appear to have a long life, and to be free from any serious amount of stretching. We were assured that there are cases where the ropes have been working for eight and nine years in spinning mills without re-splicing being necessary.—*The Engineer*, London.

POWER AND THE ENGINEER

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Progressiveness and Asininity

There is really a very narrow line of separation between real, commendable progressiveness and a stupid belief in one's ability to upset natural laws. The same underlying spirit produces both the brilliant investigator and discoverer and the pitiable dupe of his own ignorance who firmly believes in perpetual motion and the creation of energy—that is, unwillingness to accept as final the dicta of other seekers after knowledge. If we all were content with the fruits of investigations made by dead and gone physicists and engineers there would be no more progress in applied physics and engineering; neither would there be the perennial crop of perpetual-motion and similar misguided inventors.

There is one supreme test, however, which invariably differentiates an intelligent investigator from a self-centered fool: the application of established natural laws to his ideas. The work of the former type of man is always in conformity with the fundamental laws of nature which have been proved to be sound, while that of the false prophet is always based on a violent distortion or total disregard of all physical laws applying to his problem; the former never tries to upset the laws of gravity and of the conservation of energy, whereas the latter invariably manifests a lofty contempt for theory and a valiant determination to force tribute from Nature without giving up an equivalent.

Safety Valves

For years the rule of the Board of Supervising Inspectors of the Steamboat Inspection Service of the United States, which was our principal if not our only official expression upon the subject of safety-valve capacity, was one square inch of safety-valve area for each three square feet of grate surface. Gradually it became apparent that the grate surface, apart from the rate of combustion, was no measure of the steam-making capacity of a boiler, and that a given orifice would discharge more steam at a higher than at a lower pressure, in fact, that the weight discharged per unit of time was in direct proportion to the absolute pressure.

Five years ago the board adopted the following formula devised by L. D. Lovekin, chief engineer of the New York Shipbuilding Company:

$$Area = 0.2074 \frac{Weight\ of\ steam\ per\ hour}{Absolute\ pressure}.$$

The derivation of this formula is explained on page 473. It is based upon Napier's approximate formula for the flow of steam through an orifice:

$$W = \frac{A\ P}{70},$$

where the weight, W, is in pounds per second, the area A in square inches and pressure P in pounds absolute.

Mr. Lovekin's formula is based upon the assumption that the valve lifts one-thirty-second of its diameter, i.e., that a one-inch valve will lift one-thirty-second of an inch and a six-inch six-thirty-seconds, or three-sixtenths; and the coefficient 0.2074 comes by multiplying the 70 of Napier's formula by 32 and dividing by 3600, to reduce the area required to release the given weight in a second to that required to release it in an hour, by 0.75 chosen arbitrarily "for safety" and by 4, which is the 4 of the common expression for area:

$$Area = d^2 \frac{\pi}{4} = d^2\ 0.7854,$$

the π canceling out. If the weight W is taken as per square foot of grate surface the area must, of course, be multiplied by the number of square feet of grate surface involved, and this may be an excuse for striving for accuracy in the coefficient, for any inacuracy would be multiplied in proportion; but it is difficult to see the necessity or sense, in a formula based upon Napier's confessed approximation, involving an assumed lift, which the valve will hit only by accident, including an arbitrarily chosen factor of safety, and used to indicate the next larger size of valve commercially available, of carrying the coefficient out to four places of decimals. If the formula had been written:

$$A = 0.2 \frac{W}{P},$$

it would have been more simple and sensible and would have indicated the same size of valve in any case except where the present rule falls just above an available size.

But the experiments made by Mr. Darling and reported on pages 473+, as well as the discussion at the meeting at which the paper was presented, brought out the fact that safety valves do not lift in proportion to their diameters; that the lift is practically the same for a large, as for a small valve, smaller for the larger valve if anything, and is around three-thirty-seconds of an inch for all valves in normal condition. The recognition of this fact makes a beautifully simple formula possible.

The area available for the discharge of steam with a flat-seated valve is the product of the circumference and the lift, or with a beveled seat, the above product multiplied by the sine of the angle which the seat makes with the vertical axis. If the Napier formula,

$$W = \frac{A\ P}{70},$$

be multiplied by 3600 to express W in pounds of steam to be discharged per

hour instead of per second, and transposed to indicate the area required, it will read:

$$A = \frac{70\,W}{3600\,P}.$$

If A be taken as the product of the circumference and the lift ($d \times 3.1416 \times l$), and the lift be assumed as one-sixteenth of an inch,

$$\frac{d \times 3.1416}{16} = \frac{70\,W}{3600\,P}$$

or

$$d = \frac{16 \times 70 \times W}{3.1416 \times 3600\,P},$$

and

$$d = 0.1\,\frac{W}{P},$$

almost exactly.

Dividing the weight of steam to be delivered per hour by the absolute pressure of that steam and moving the decimal point one place to the left would give the diameter of valve required directly, without any reference to tables of areas and, the available area varying directly as the diameter, the result can be proportioned among a number of valves, if too large for one, by simple division. If the rule indicated 12 inches of diameter two 6-inch, or three 4-inch valves could be used.

For the common 45-degree beveled seat the constant would become 1.4; but if the lift be assumed to be 0.0714 instead of one-sixteenth or 0.0625 the constant will return to 0.1. This is less than $\frac{5}{64}$. Mr. Lovekin's rule has been assuming that a three-inch valve lifts $\frac{5}{64}$ or $\frac{6}{64}$, and any maker will guarantee a valve of any size to lift three thirty-seconds, when the valve pops, and to stand at that hight so long as the pressure is maintained. Should the pressure increase the valve is free to open farther, and more of the higher pressure steam will escape through the same area due to its greater density so that there is an ample margin of safety. Mr. Lovekin's rule has proved ample and the proposed rule gives the same results for valves 2.64 inches in diameter, requires less diameter of valve below this and more than his formula does for diameters greater than 2.64 inches.

The purpose of a rule for safety valves is not to determine with mathematical precision the exact area required to discharge a given amount of steam per second, but to indicate a size of valve which will be ample for that service without being so large as to discharge the boiler too quickly or to be extravagant in cost. The proposed rule is simpler and safer than the present, is more consistent with the governing facts, if, as it appears, the lift is practically the same for all sizes of valve, and will, we believe, indicate valves ample to discharge the assumed amount of steam, but not needlessly large.

In estimating the quantity of steam which the valve may be called upon to discharge it should be borne in mind that the maximum rate of evaporation for a few minutes is apt to considerably exceed the average rate. The performance of a boiler for an hour is the aggregate result of varying conditions of fire, draft rate of feed, etc. The momentary evaporation under favorable conditions may be considerably more than the average evaporation for the hour.

The establishment by Mr. Darling of the fact that Napier's formula applies so closely to the discharge from a safety valve is very gratifying. It remains to be determined if any allowance is required for superheated steam within the limits of ordinary practice.

Be Exact

In all professions it pays to be exact in thought and statement, oral or written, and more especially does this apply to engineering. Although a great many engineers are, perhaps, exact enough in thought, there is a general tendency to be careless in the expression of the thought. To a certain extent this is only natural, for back of the statement, in the mind of the writer, is the idea, and the meaning to him is perfectly plain, but to the reader, who sees only the expression, the statement not only may not be clear, but is often misleading. Long-continued carelessness in this regard will surely leave its mark, and in time the careless writer becomes the careless thinker; and the same characteristic will creep into the solution and computation of the problems which enter into the everyday life of the engineer.

Many errors have been caused by the careless use of the word "pressure," or failure to specify what pressure is meant. Customary use of the word in connection with steam practice refers to pressures per square inch above the pressure of the atmosphere, as indicated by an ordinary gage. But many calculations require the pressure to be taken in pounds absolute, i.e., in the quantity indicated by an ordinary pressure gage plus the pressure of the atmosphere. In other calculations the pressures must be taken per square foot; and often pressures which should be taken in millimeters of mercury or kilograms per square centimeter are thoughtlessly taken in the customary pounds per square inch.

Other words, such as work, power, energy and force, are often misused. To learn the proper definition and how to use each word in its right place requires only a few minutes and is surely worth the effort.

Another error of common occurrence is found in the expression of the number of heat units in water at a certain temperature; that is, if the water is at a temperature of 150 degrees Fahrenheit, it is not uncommon to be informed that it contains 150 B.t.u., when as a matter of fact it contains only 118 B.t.u., the starting point of 32 degrees Fahrenheit, from which the amount of heat is reckoned, being entirely overlooked. A designation should always be made as to what thermometrical scale the temperature applies. There are a great many other things along this line requiring the same attention.

The Care of Commutators

Several times we have heard of operating engineers who claim to use emery habitually for smoothing off commutators, and with no bad results. One well known contributor to our columns says he has used it for years without any resultant difficulty whatever, and we do not question his veracity in the slightest degree. The number of men who have reported favorable experience with emery, however, is small; the number who have brought trouble upon themselves is large. In a practical operating experience of nine years the present writer has never but once seen emery used for the purpose mentioned without producing worse trouble than that which it was intended to cure; the exception was explained by the facts that no lubricant was used on the commutator and the mica between the bars was unusually thick and of just the quality to match the copper in its rate of wear. Wherever a commutator is lubricated, the use of emery is very likely to be followed by "leaks" across the mica strips which separate the commutator bars. Of course there may be cases where this does not happen. There have been many cases of recovery by persons who have received shocks from circuits of deadly voltages, but this does not prove that caressing a bare high-tension conductor is a safe habit to form.

The more progressive city libraries of the country are paying increased attention to engineering and technical subjects in their work with the public. Among those which are especially active in this field is the Public Library of Washington, D. C., as shown by the annual report for 1907-08, just issued. This institution has organized a special department, the Useful Arts Department, to meet the demands of its readers for books on the engineering branches, trades and handicrafts, business and industries in general. Here on open shelves are placed about 6000 selected volumes, purchased very largely within the last three years and many of them expensive. Over 160 periodicals are received, which include nearly all the important American publications and some foreign. Business, general science, decoration and ornament, marine and municipal engineering, construction, printing, griculture, are all represented.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

"Schutte" Electric Motor Operated Gate Valve

The "Schutte" precision electric motor-operated gate valve is illustrated in Figs. 1 and 2. The loose-fitting handwheel has a vertical movement on the upper end of the yokenut to which it is clutch-connected only when in its lowest or hand-operating position; this step-clutch is formed on the handwheel hub, around which there is a continuous rim, the latter engaging with the two extensions of a pivoted or hinged-gear clutch lever, the heavy end of which, when lowered, engages with a narrow lug on the inside of the rim of the large spur gear also loosely mounted on the yokenut below the clutch collar that carries the aforesaid hinged lever. As this hinged clutch lever and the lug on the inside rim of the gear are both narrow, the gear can make about ⅞ of a revolution for impact and for the purpose of allowing the motor to acquire speed.

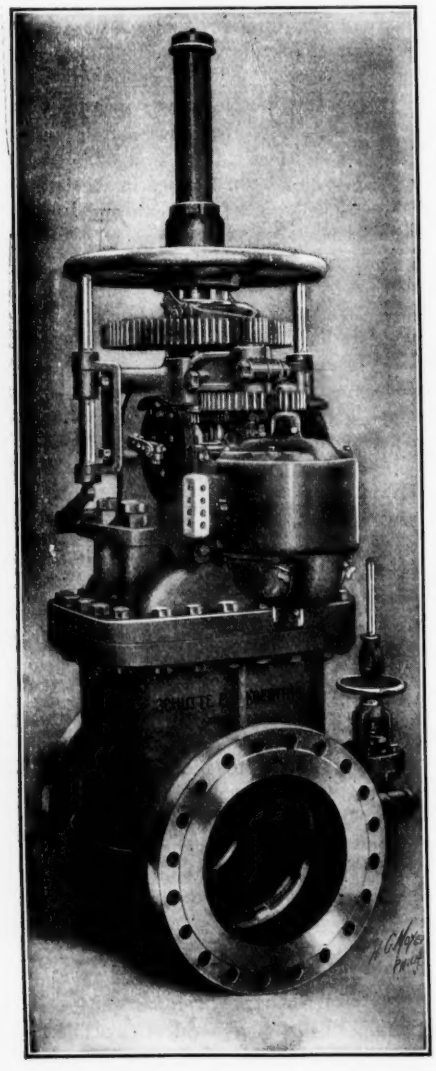


FIG. 1

When the valve is used for motor operation the handwheel is prevented from revolving and held in its highest or out-of-gear position by the two vertical lever-supported rods resting against the under side of the handwheel rim. From this it will be seen that the handwheel is entirely cut out when the valve is being operated by a motor and can therefore exert no jamming action at the end of travel due to the stored-up inertia, nor does power have to be exerted to set it in motion even frictionally.

The handwheel and gearing as described interlock so that both cannot be out of action at the same time, nor can both be in action at the same time. When the handwheel is in use the motor gearing is disengaged and *vice versa*.

As these valves are intended for operation from a distance, such as from a different floor where the operator at the reversing controller is unable to see in what position the gearing has been left, an instruction plate is provided on each arm of the yoke, so as to insure that the gearing is left ready for emergency use. It is placed on the side opposite to that shown in the illustration and reads: "Always leave valve ready for motor operation with handwheel in highest position;" the raising and lowering of the wheel being accomplished by means of a screw spindle attached to a central lever on the rock-shaft carrying the side levers that raise and lower the supporting rods.

To cut the motor out at the proper time, two travel-limit switches are provided, one for the upward and one for the downward stroke; these close the circuit on a shunt trip coil in the controller so that the latter will be thrown to its off position, thereby informing the operator that the valve has made its complete upward or downward travel, as the case may be. In addition to this a double-pole circuit-breaker is used to guard against burning out of the motor or controller from overload.

These valves find special application as an emergency shutoff on steam mains between boiler and engine, or in turbine rooms. They are fitted with motors for either direct or alternating current of any standard voltage.

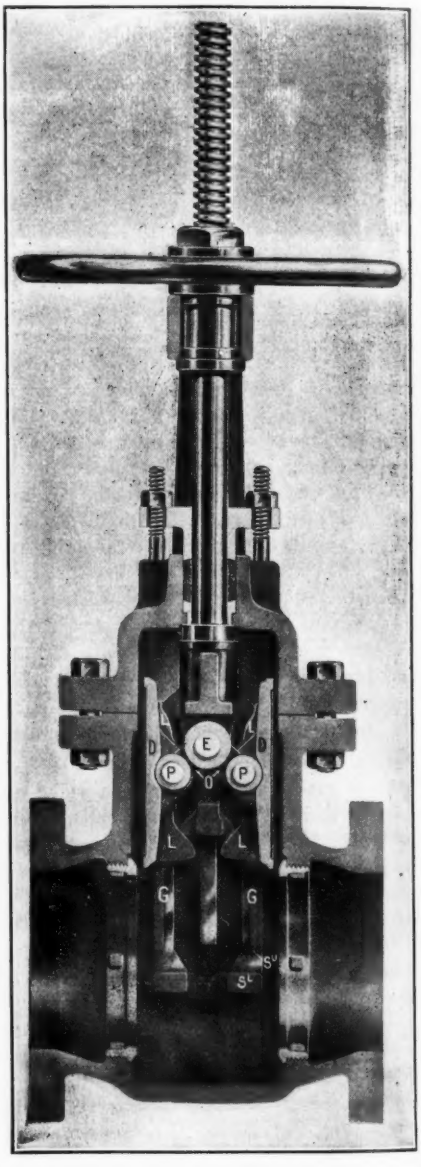


FIG. 2

To guard the threaded valve spindle from grit or dirt, and to insure a clean, oiled surface, a protecting sleeve is screwed to the upper end of the handwheel hub.

The motor is of special construction, fully incased, provided with self-oiling bearings, of large overload capacity and capable of standing the heat of high-temperature steam to which the valves are subjected.

As gravity is used to engage and disengage the motor gearing and keep the handwheel in its lowest position, these valves must be used with the spindle vertical and with mechanism on the top as shown. They can, however, be fitted with a spring so that the spindle may be used in a horizontal position and the valve may be used inverted.

Fig. 2 is a sectional view of the valve proper, *G G* being the guides which keep the valve disks *D D* in place, the whole being made tight by means of the leverage due to the arrangement shown at *P*, *E* and *L*.

This valve is manufactured by the Schutte & Koerting Company, Twelfth and Thompson streets, Philadelphia, Penn.

Westinghouse Large Direct Current Motors

The accompanying engravings illustrate a line of direct-current motors recently brought out by the Westinghouse Electric and Manufacturing Company in order to meet a growing demand for machines of larger size than the ordinary direct-current lines supply. These machines, known as Type E M, are built in capacities ranging from 90 horsepower upward

FIG. 1. WESTINGHOUSE HEAVY-DUTY MOTOR

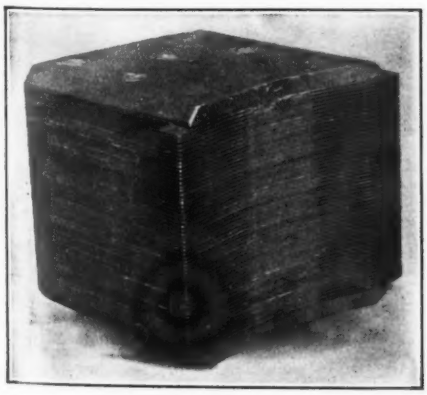


FIG. 2. MAGNET POLE OF WESTINGHOUSE MOTOR

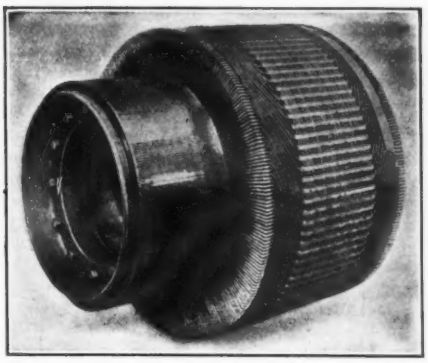


FIG. 3. WESTINGHOUSE ARMATURE AND COMMUTATOR

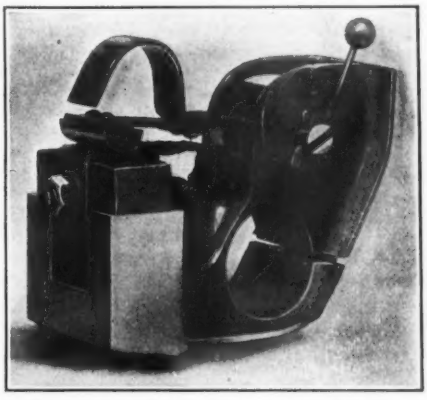


FIG. 4. BRUSH AND HOLDER OF WESTINGHOUSE MOTOR

and for all standard direct-current voltages. They are supplied with a standard bed frame and pedestals, as illustrated in Fig. 1, or without bed and pedestals, for direct mounting.

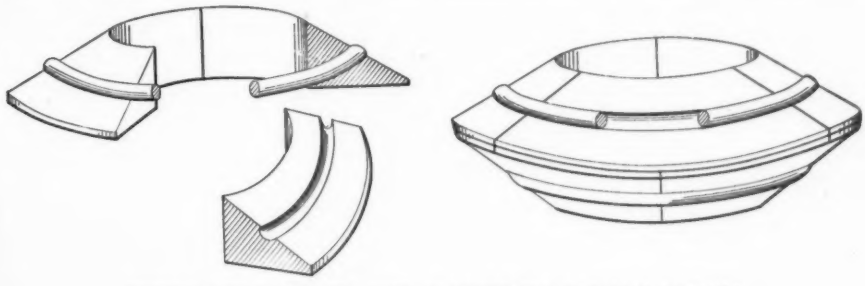
The field magnet consists of a cast-iron yoke ring with laminated magnet poles bolted to the ring. The magnet poles are built up of relatively thick sheets of steel; one pole-tip corner of each sheet is cut off and the sheets are assembled with the remaining tips staggered, as close inspection of Fig. 2 will reveal. This gives extremely high magnetic density at the tips, tending to stability of field at the edges of the air gap, of course, and resultant improvement in commutation. The field winding is shunt, series or compound, according to the requirements. All three classes of winding are standardized, so that no special construction is necessary in order to use any one of them. The field-magnet coils are wound on heavy paper cores or bobbins and treated with a waterproof insulating compound, but they are not wrapped with tape; better radiation is obtained by leaving the surfaces unwrapped.

The armature is of the familiar slotted-core type, with a lap-connected winding of individually insulated coils. The core disks and commutator are mounted on a shell or drum with a central spider into which the shaft fits. This construction permits the shaft to be removed and replaced without disturbing the armature-core disks or the commutator connections. The armature winding is equipped with equalizing connections housed in the rear "overhang" of the winding, which is protected against centrifugal force by a band of binding wires, as shown in Fig. 3. This engraving illustrates the general construction of the armature and commutator; the end of the spider into which the shaft fits is just visible within the commutator core. The armature winding is held in the core slots by wooden wedges.

The brush holders are of the simple box type shown in Fig. 4. The brush is pressed on the commutator by a flat spring coiled about an adjustable spindle and a finger loop is riveted to the spring for convenience in lifting the spring away from the brush. The latter is a rectangular carbon block with a flat flexible "pigtail" attached to its upper end by means of a strap and a bolt; the nut on the end of this bolt is held in place by a lock washer. The commutator construction is along the well known standard lines of Westinghouse practice, as is also that of the self-oiling bearings and pedestals.

"Faultless" Metallic Packing

"Faultless" metallic packing is manufactured by the Hoyt Metal Company, 325 Locust street, St. Louis, Mo. The metal used in this packing is said to be of a special mixture, made in the form of rings turned in a lathe to the diameter of the rod and cut into three sections. The sections are held together by wire springs. The rings are in pairs, with the flat sides together. Metal rings with concave sides hold the packing rings to the rod, with a ball-and-socket and sliding-joint effect. The construction is shown in the illustrations.



SECTION AND COMPLETED RING OF FAULTLESS METALLIC PACKING

The rubber section of the ring is of especially prepared stock, which is said to be unaffected by steam, oil or ammonia. The rubber does not come in contact with the rod, but acts as a cushion to take up vibration, there being a continuous metal surface beyond the rod.

Obituary

Francis H. Boyer, 64 years old, died at his home in Somerville, Mass., Sunday, February 21. Mr. Boyer was a widely known mechanical engineer and architect, at one time superintendent of the refrigeration department of the De La Vergne company and later master mechanic for the John P. Squire Company. He was a member of the A. S. M. E., and once served on its board of managers for three years. He also belonged to the N. A. S. E., and other engineering organizations. Latterly Mr. Boyer was in business with his son, Charles W. Boyer, manufacturing refrigerating and ice-making machinery, designing abattoirs, building water-cooling towers and coal-handling and conveying machinery.

Business Items

Richard Thompson has opened an office at 123 Liberty street, New York, for the sale of steam specialties.

The York Manufacturing Company, York, Penn., manufacturer of ice and refrigerating machinery, reports 28 recent orders aggregating 1350 tons of refrigeration.

E. J. DuBois, son of William J. DuBois, in charge of the engineering of the fleet of the United Fruit Company, and prominent in M. E. B. A. circles has accepted a position with the sales department of the William B. McVicker Company. His especial attention will be given to marine business.

The "Selden and Zena" packing has just been furnished for use on the plungers of the pumping engines at the waterworks in St. Petersburg, Russia. These packings are made by Randolph Brandt, 72 Cortlandt street, New York, who also advises us that a number of pump manufacturers use these packings for outside-packed plungers, this packing being specified by many chief engineers.

The Hughson Steam Specialty Company, 960 South Halstead street, Chicago, Ill., has succeeded the John Davis Company, of Chicago, in the manufacture of the "Eclipse" steam specialties. George F. Hughson, who is president of the new company, was the original owner and inventor of these specialties, which include regulating, back-pressure relief and blowoff valves, pump regulators, steam traps and separators. All of the former agents of the John Davis Company will continue to handle these goods.

G. J. Burrer, proprietor of the Sunbury Flour Mill and electric-light plant at Sunbury, Ohio, in a letter to the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, says: "I find the skimmer all right. My boiler has not foamed since I put the skimmer in. When I put the device in there was ⅛ inch of scale on the tubes, and in three weeks they were as clean as could be. I opened the boiler again on Monday and there was not a particle of dirt or mud in the back head, but I took out two gallons of scale from the front head.

"Aid to Shippers" is the title of a 72-page book containing a quantity of information of value to all engaged in the export or import trade. The book is issued by Oelriches & Company, of New York, for more than forty years the American representatives of the North German Lloyd Steamship Company, who, by reason of long experience, are qualified to advise. The table of foreign moneys with United States equivalents, together with weights, measurements, tariffs, customs requirements, etc., will be found of value. A copy of this book will be sent, postpaid, on request to Oelrichs & Company, Forwarding Department, 5 Greenwich street, New York.

Among the recent orders taken by the Crocker-Wheeler Company, of Ampere, N. J., is one for a 250-kilowatt, motor-generator set for the Tennessee Coal, Iron and Railroad Company, at Ensley, Ala. It will consist of a 250-kilowatt 275-volt direct-current generator driven by a 6600-volt 3-phase 25-cycle synchronous motor, and will be used as an exciter. Another order is one for about 50 horsepower of small elevator motors purchased by the Haughton Elevator and Machine Company, Toledo, Ohio. Yawman & Erbe, of Rochester, New York, have also placed orders for a number of 2/5-horsepower motors for use on some of their specialties.

The Missouri Valley Milling Company, Mandan, North Dakota, has given contract to the Minneapolis Steel and Machinery Company, for furnishing and installing the complete power plant for a new mill being built at Dickinson, North Dakota. The contract includes one 12 and 26x36 heavy-duty cross-compound Twin City Corliss engine, with evaporative surface condenser, a 300-horsepower feed-water heater and purifier, a boiler-feed pump, pumps for fire service, a 50-kilowatt direct-current generator, switchboard and motor, one 5000-gallon wooden water tank, oil and steam separators, miscellaneous transmission machinery and all piping, valves and fittings.

J. E. Lonergan Company has been incorporated in Pennsylvania, with a paid-in capital of $200,000, to succeed to the business of J. E. Lonergan & Company, 211 and 213 Race street, Philadelphia, Penn. The new company will have the following officers: John E. Lonergan, president; M. A. Hudson, vice-president; H. S. Whitney, secretary; W. E. Crofton, treasurer; directors, John E. Lonergan, M. A. Hudson, H. S. Whitney, W. E. Crofton, James F. Lonergan. H. S. Whitney and M. A. Hudson were connected for many years at New York and Chicago with Manning, Maxwell & Moore. W. E. Crofton, for the past 26 years, has been cashier and head bookkeeper for J. E. Lonergan & Company.

The International Acheson Graphite Company, of Niagara Falls, advises us that it is the only maker of graphite in the world. It operates the electric-furnace process, and thus the company is in full control of every ounce of raw material that enters its furnaces, while it also controls the application of the furnaces during the entire period of their operation. Because of these facts and the thorough scientific skill applied, this company makes what it calls, "grade 1340 Acheson-Graphite," guaranteed to be at least 99 per cent. pure, very fine, soft, lusterless and unctuous. The company's claim is that this is the best lubricating agent now known, as it is not tough, and has those spreading qualities so necessary to ideal lubrication.

The Keystone Lubricating Company, Philadelphia, manufacturer of Keystone grease, has recently been advised of the efficiency and economy of this product in the lubrication of governor pins of an installation of Westinghouse high-speed engines at the plant of the Electric Storage Battery Company, Philadelphia. In this type of flywheel governor the conditions of safe and effective lubrication are severe, as the governor pin carries a pair of heavy weights and oscillates through a short arc only for its maximum travel between light load and full load on the engine. The chief engineer, reporting on the performance of Keystone grease, states that it gives perfect satisfaction, with a consumption of four to six ounces of No. 2 density grease on each engine per week of thirteen consecutive shifts.

Help Wanted

Advertisements under this heading are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

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WE WANT REPRESENTATIVES to handle metallic packing in Pittsburg, Cleveland and Cincinnati. National Metallic Packing Co., Oberlin, O.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION as fireman, oiler or wiper in power plant by I. C. S. student. No experience, but not afraid of hard work. Box 7, POWER.

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IN ORDER TO SETTLE an estate, an attractive opportunity is open to a party with $150,000.00 competent to fill responsible position either in the scales or manufacturing department, to purchase an interest in a well and favorably known, profitable machinery manufacturing plant located in Pennsylvania, with an office and established trade in New York City. Address "Executors," Box 3, POWER.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—Three 1-in. Worthington duplex plunger, all brass, hot water test meters. W. H. Odell, M.E., Yonkers, N. Y.

FOR SALE—The Helvetia Leather Company of Lancaster, Pa., capital $15,000.00. Big chance for live buyer. For full particulars address, B. C. Atlee, Lancaster, Pa.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

SECOND-HAND MACHINERY FOR SALE—Engines, milling, linseed and cotton seed oil mill machinery. Write us for description and prices. Indiana Machine and Supply Co., 203 Ingalls Building, Indianapolis, Ind.

ONE 14x36 Vilter Corliss engine, with 7' tandem air compressor; one 14x36 Nagle Corliss engine. Can be seen under steam. Guaranteed in first-class condition; selling on account of change in equipment. Ontario Silver Co., Muncie, Ind.

FOR SALE—Three Fraser & Chalmers horizontal cross compound non-condensing Corliss engines, with 10" high pressure and 14½" low pressure cylinders of 24" stroke. Each engine provided with two belt flywheels, 10' diameter by 12" crown face. All in first-class condition. For further particulars write New Prague Flouring Mill Co., New Prague, Minn.

Typical Low-Pressure Steam Turbine Plant

Double-flow Turbine Utilizing the Exhaust of Two 750-Kilowatt Corliss Engines. No Governor, and Capacity Varies with Initial Pressure

BY J. R. BIBBINS

Probably the first application of the low-pressure type of steam turbine to commercial work in connection with American mining properties is to be found in the power plant of the U. S. Coal and Coke Company, Gary, W. Va. Considerable progress has been made in this country in the low-pressure turbines in connection with light and power plants, and this installation will serve as an illustration of the possibilities of this type, not only in mining properties, but also in other industrial work where similar conditions of power service are encountered.

FIG. 1. TURBINE INSTALLATION AT GARY, W. VA.

Power Plant

The Gary plant was installed in 1903 with an equipment of two 400-kilowatt generators, each driven by two simple Harrisburg engines which were later changed to cross-compound engines. In 1904, a 750-kilowatt cross-compound Corliss engine-driven unit was added, and in 1905 a duplicate unit, aggregating 2300 kilowatts in engine-type units. On account of installing some new machinery, a low-pressure turbine was added in 1907 to utilize the exhaust from the Corliss engines—also a complete expansion turbine, both of standard Westinghouse construction. Each of these drives a 1000-kilowatt generator.

The property at Gary, W. Va., consists of eight coke plants and four coal mines, all electrically driven with the exception of the hoisting engines and fan at one of the mines, which is a shaft; hence, the plant is subject to a combination load from a large number of rotary converter sets which furnish direct current for mine locomotives, pumps, coal-cutting machines, larries and coke-drawing machines, and for a large number of induction motors which drive shop machinery, pumps, crushers, picking tables, compressors, conveyers, etc.

The present equipment consists of two 400-kilowatt generators driven by 20x23½x20-inch Harrisburg engines; two 750-kilowatt generators, each driven by 24x42x42-inch Corliss steam engines; one 1000-kilowatt Westinghouse single-flow steam turbine, and one 1000-kilowatt Westinghouse double-flow low-pressure turbine.

This equipment occupies a building 43x183 feet, with an additional 18-foot longitudinal bay for auxiliaries, etc. The 2000-kilowatt capacity in turbines occupies about one-third of the building, and the 2300-kilowatt engine-driven units occupy about two-thirds of the building.

It should be noted that the low-pressure turbine receives steam only from the two Corliss engines. The Harrisburg engines, although exhausting into the common main, are practically never operated dur-

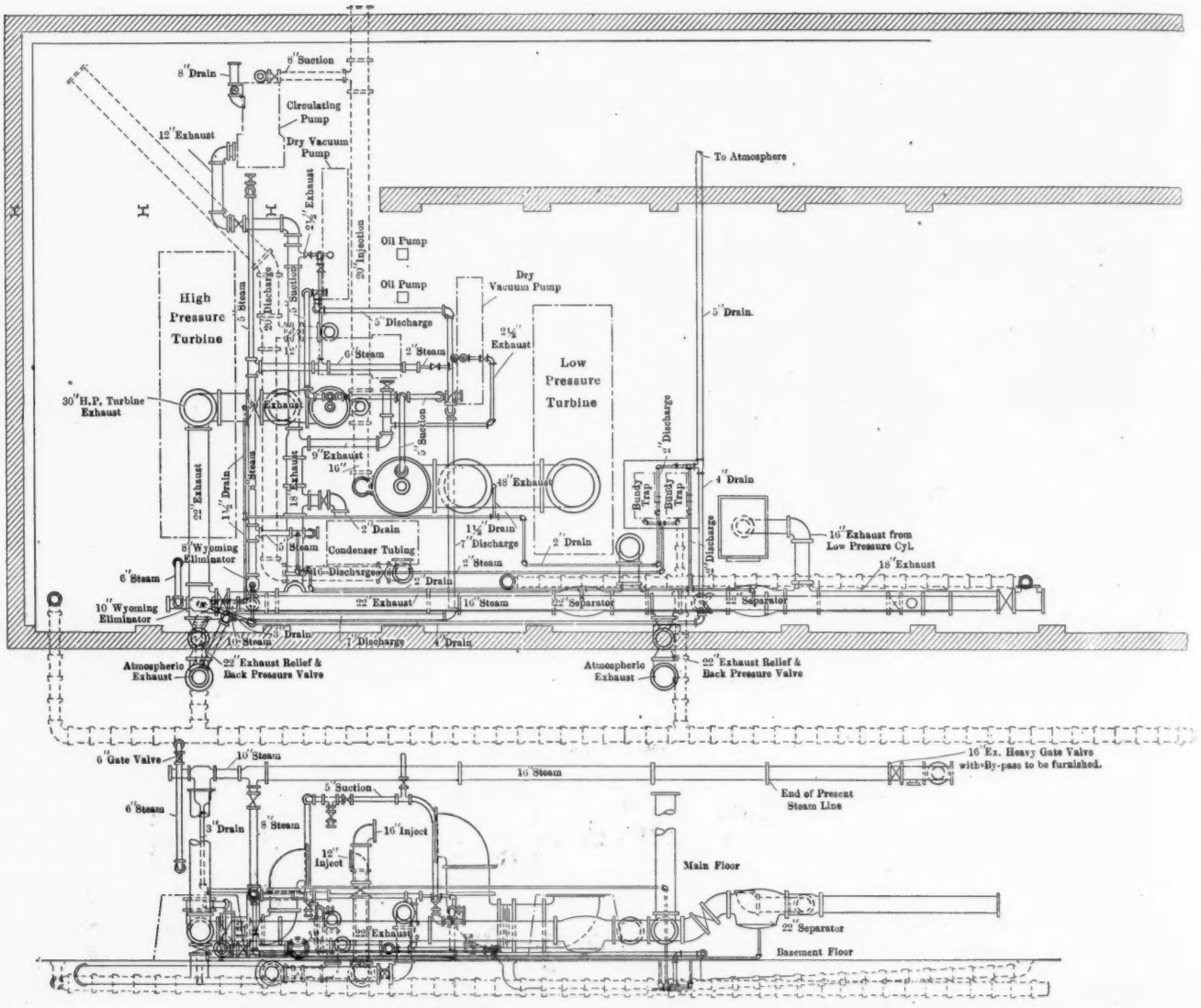


FIG. 2. PIPING PLAN AND ELEVATION OF TURBINE EXTENSION TO POWER PLANT

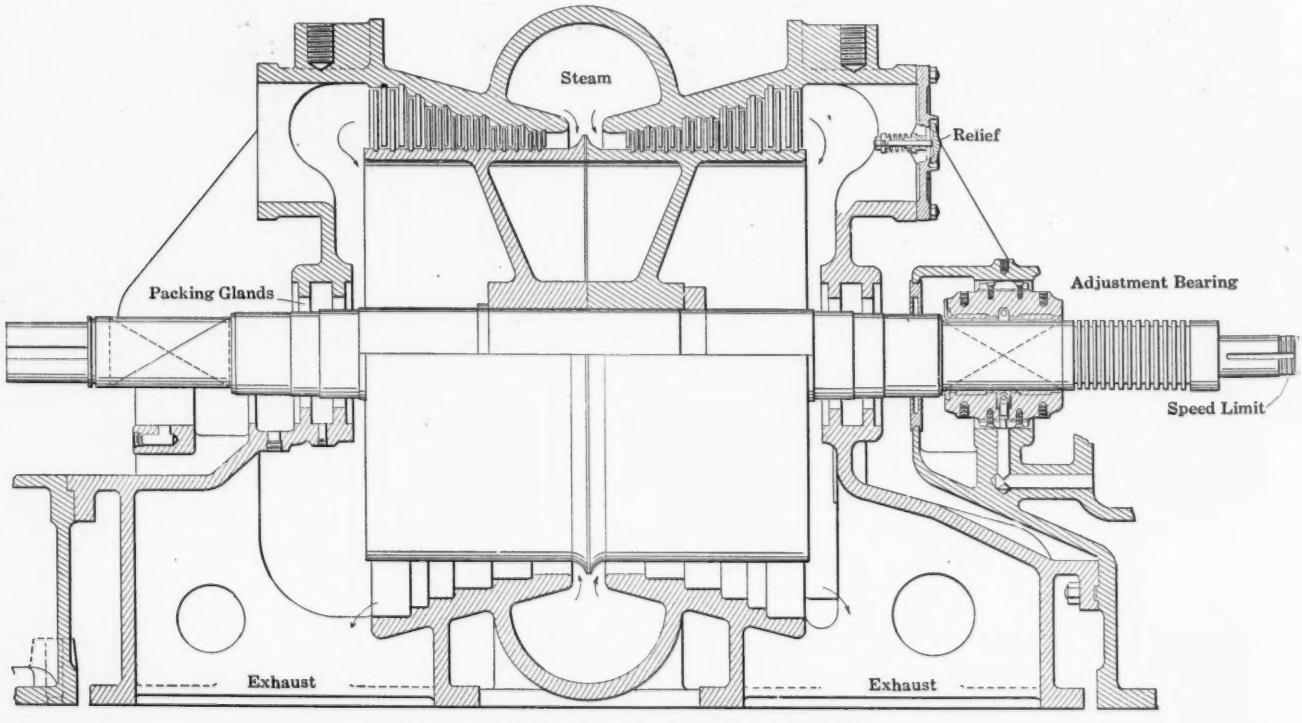


FIG. 3. SECTION THROUGH LOW-PRESSURE TURBINE

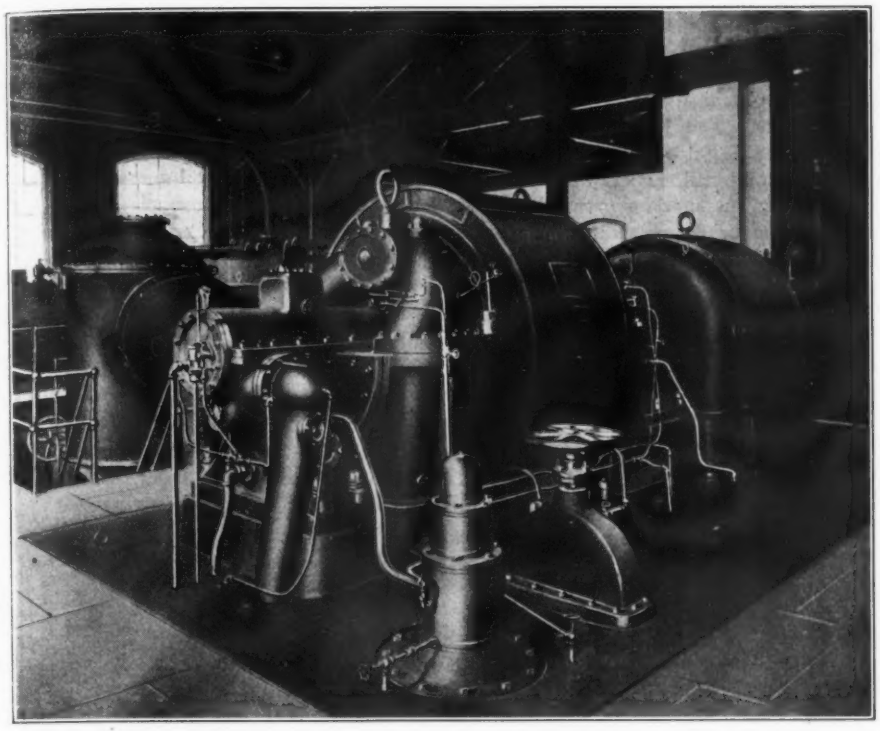


FIG. 4. LOW-PRESSURE TURBINE WITH THROTTLE VALVE IN FOREGROUND

COMPARATIVE DATA.

	Low Pressure.	High Pressure.
Length of turbine	11′ 5″	17′ 3″
Length of generator	12′ 5″	11′ 10″
Length of unit	23′ 10″	29′ 1″
Width of bed	6′ 8″	6′ 6″
Hight, floor to center line	3′ 11″	2′ 7″
Hight over all	7′ 3″	8′ 4″
Diameter steam pipe	22″	6″
Diameter exhaust pipe	48″	30″
Inlet pressure, lb	15	125
Quality of steam	Sat.	Sat.
Vacuum (rfd.)	26″	26″
Speed, r.p.m	1500	1500
Rated capacity, kw	1000	1000
Overload	....*	50%

*Overload based on initial pressure.

ing the day. This exhaust steam is all sent to heaters in the boiler room and a valve in the exhaust header is provided to separate these engines from the remainder of the system, so that the low-pressure plant at Gary is only concerned with the 1500-kilowatt capacity in Corliss engines.

Turbine Types

An interesting comparison of the two types of turbine unit is afforded by these two machines which are of equal capacity. It will be noted from the accompanying table that the low-pressure turbine is one-third shorter than the high-pressure machine, but the hight and width are about the same, the exhaust area of the high being 2.5 times greater. The generators both deliver three-phase power at 6600 volts and each revolves 1500 revolutions per minute. The fields are strap-wound and the armatures form-wound with coils held in place by overhanging tips of the laminated teeth. A puncture test of 15,000 volts was made on the armature winding and 1000 volts on the field. The generators will not exceed 40 degrees rise at continuous full load with a power factor ranging from 90 to 100 per cent., and at this load will give an efficiency of 94 per cent., including iron and copper losses.

The complete-expansion turbine unit has an overload capacity of 50 per cent., but the low-pressure turbine unit, being dependent upon a fixed initial pressure of 15 pounds absolute, can have no overload unless the initial pressure is raised. But with 18 pounds initial pressure, an overload of 25 per cent. would be realized; with longer cutoff on the engines, an initial pressure of perhaps 25 pounds would be obtained with correspondingly greater overload.

Governing

Owing to the service conditions arising in this plant, the simplest system of gov-

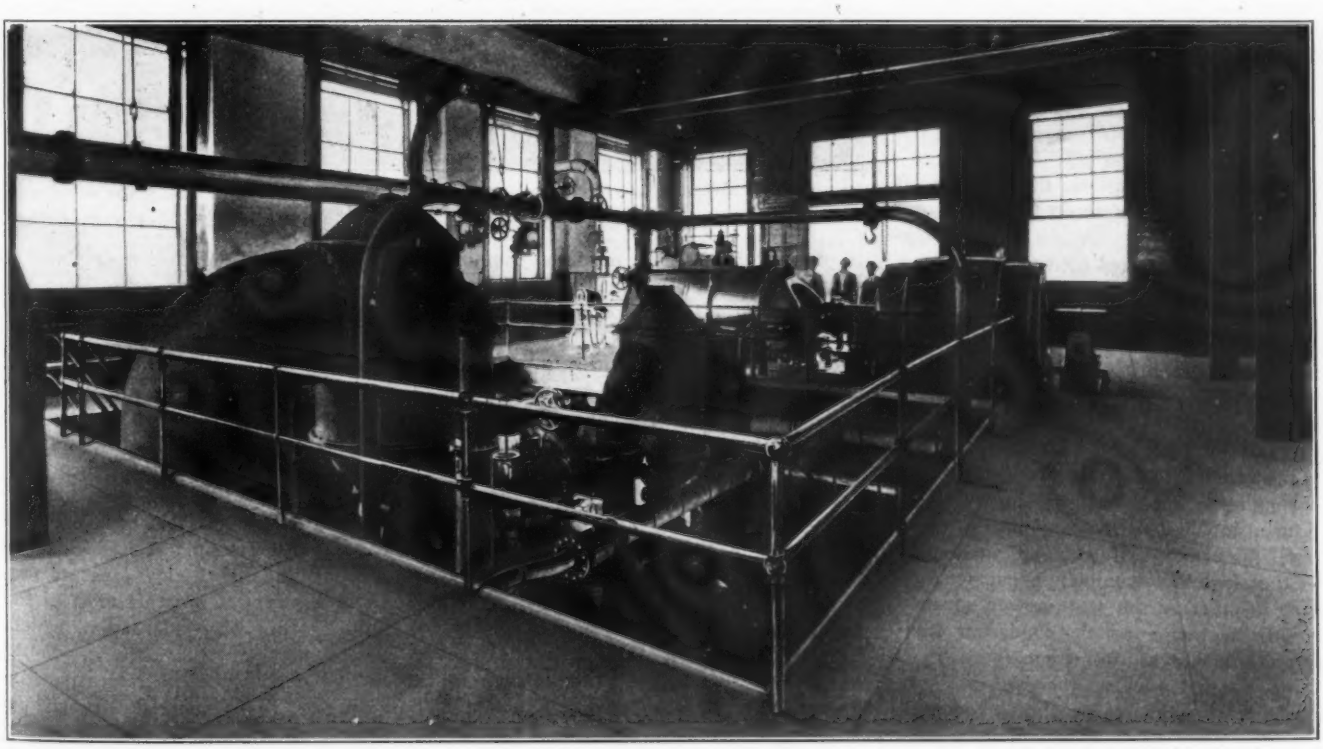


FIG. 5. CENTRIFUGAL JET TYPE TURBINE CONDENSERS

erning has been adopted for the low-pressure unit. In fact, the turbine has no governor at all, but delivers its current to the same busbars as do the two engine units supplying it with exhaust steam. Under this condition, then, the low-pressure turbine is equivalent to the third cylinder of a triple-expansion steam-engine system, and instead of the turbine generator being directly driven by mechanical means from the engine shaft, it is held in perfect step by electrical means; i.e., by connecting with the same bus. It therefore occurs that with the turbine throttle valve open, the load on the turbine and engines will rise and fall together, depending upon the variations in external load, which accordingly varies the amount of exhaust steam supplied to the turbine. By reason of this arrangement, the pressure in the exhaust main varies according to the load on the entire plant, just as the receiver pressure of a compound engine varies.

The low-pressure turbine may be considered as an engine with a fixed cutoff. As the blade proportions are constant, the ability of the turbine to carry load depends entirely upon the initial pressure available; and consequently, as the load on the engine increases, the volume of steam passed per minute increases, the exhaust pressure rises and the low-pressure turbine is enabled to pass the extra quantity of steam required to generate the additional power. Thus it will be seen that this combination of prime movers presents simplicity and flexibility of operation. Under other conditions of service, where the turbine would be able to utilize but a small proportion of the exhaust steam available, it would be necessary to install a governor of the standard type which would convert the turbine into a constant-pressure instead of a variable-pressure machine, as here installed.

Turbine Construction

The construction of the turbine is clearly shown in the accompanying photographs and section. A low-pressure machine is characterized by the large steam passages necessary. Referring again to the accompanying table, the steam-supply mains to the high-pressure and low-pressure machines were 6 and 22 inches respectively; exhausts, 30 and 48 inches. It would be expected that this large difference would increase the bulk of the low-pressure machine beyond reasonable proportions, but through the adaptation of the Westinghouse double-flow design, the machine itself does not occupy even as much space as the single-flow complete-expansion turbine installed in the same power house.

On the other hand, the condenser serving the low-pressure turbine is twice as large as that serving the high-pressure machine; for the reason that in expanding the steam from boiler pressure, 150 pounds gage, down to atmosphere in the Corliss engine, nearly half of its internal work has already been expended, and twice as much steam must, therefore, pass through the low-pressure machine to do the same work as through the high-pressure turbine. The low-pressure turbine condenser at Gary, to be sure, serves 2500 kilowatts combined generating capacity, but owing to the superior economy of the combined plant, the work actually done by the condenser is much less than if serving a straight engine or turbine.

Referring to the sectional view of the turbine, it will be noted that the rotor is of simple construction and reasonable blade lengths, no balancing pistons, and a stator symmetrical in proportions. The disadvantage of excessively large exhaust areas is overcome by dividing the flow in its passage through the machine, combining the two halves in the bedplate into a single discharge to the condenser. In the foreground, Fig. 4, will be observed the automatic, quick-closing throttle which is operated by a centrifugal safety stop at the end of the turbine spindle. This is an important guarantee of the safety of the plant, for should the machine isolate itself electrically from the busbar either by short-circuiting or by an open circuit in the cable leads, the machine would be taking full steam without load. This safety stop operates at a predetermined overspeed, under 10 per cent., and closes the automatic throttle to shut down the machine. As a further precaution, a vacuum breaker may easily be operated instantly to lower the vacuum by the admission of air when the safety stop operates. Owing to the higher density, the turbine would then come to rest much more quickly than if it still were revolving in a high vacuum.

The remaining parts of the turbine conform to Westinghouse high-pressure turbine construction. One distinctive detail, however, is the rotary oil pump driven by worm gear from the turbine shaft. The wing pump is exceptionally simple and durable in construction, and requires little attention. It is located below the floor level at the base of the vertical housing surrounding the gear drive. This pump simply suffices to keep the journals flushed with oil. A complete system of strainer and intercooler provides for continuous return of the oil to the bearings. This apparatus, together with the steam strainer, is located beneath the steel floor plates at the side of the machine.

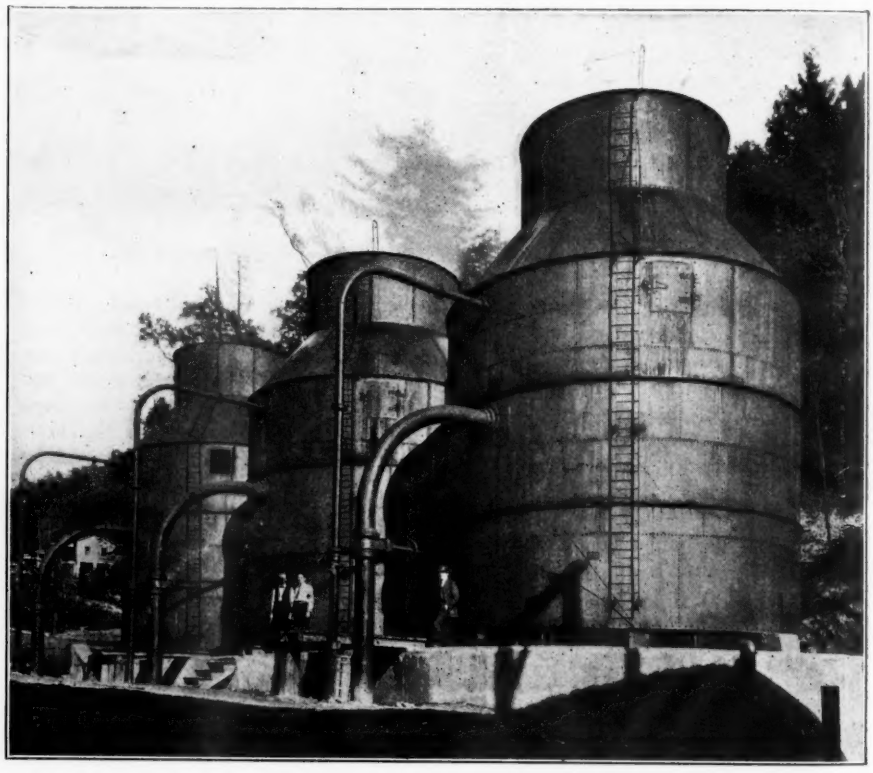


FIG. 6. BATTERY OF THREE ALBERGER COOLING TOWERS

Piping

Reverting to the plant arrangement, Fig. 2 shows in plan and elevation the general piping layout. It will be noted that all turbine-plant auxiliaries exhaust into the main low-pressure line in common with the steam engines. They do not appear to be affected by the variable back pressure of the exhaust system. A 22-inch separator on the side of the low-pressure turbine intake serves to abstract most of the suspended water of condensation, which, if passed through the turbine, would simply be detrimental in increasing the fluid friction. The piping is arranged so that feed water may be drawn either from the condenser hotwell, or the water-service main. In any event the feed would

all pass through a Cochrane heater, where the oil coming over from the engines and pumps would be largely removed. Since the low-pressure plant went into commission, a 3-inch live-steam connection has been made to the exhaust main through a reducing valve set at seven pounds. This is intended for emergencies only, to provide for either one or both Corliss engines being inoperative. It has been of service on several occasions to provide considerable overload capacity on the turbine during a deficiency of engine steam.

Condenser Plant

Both condensers are of the Alberger centrifugal jet type provided with individual turbine-driven circulating pumps and engine-driven dry-vacuum pumps. All of the circulating water is cooled by a battery of Alberger cooling towers located a short distance away, each measuring 24 feet in diameter by 34 feet high. These are of a recent type, but standard in regard to the cooling surface employed. A distributor of the "Barker's Mill" type delivers the hot water at the top of the tower. But the draft fan, instead of being located as is ordinarily the case, at the base of the tower, is here installed horizontally in the contracted stack, the fan blades covering the entire area of the stack, which is 11 feet in diameter. This fan is driven at a speed of 175 revolutions per minute by a small Pelton waterwheel which, in turn, is supplied by a small turbo-pump located in the power house. With this arrangement the tower operates upon the induced-draft principle, and it is permissible to lower the shell some 5 or 6 feet below the standard type of tower with base fans, thus effecting a considerable saving in the hight to which the water must be elevated. Of the three towers installed, two were normally employed to serve the combined engine and low-pressure turbine plant, and the third, the high-pressure turbine. Thus far, good service has been obtained from this plant. Considering the combined plant only, with the two engines running and an engine load of 1400 kilowatts, the low-pressure turbine carried 1200 kilowatts with an inlet pressure of 16 pounds absolute and a vacuum of 25.8 inches, due to the high temperature of the injection water, 88 degrees, at the time. These observations were taken during hot weather; and with an increased vacuum, 28 inches, as in colder weather, the turbine would carry loads up to 1500 kilowatts.

E. O'Toole is general superintendent of the plant, and Howard N. Eavenson, chief engineer. The latter reports that with the relief valve set at 16 pounds absolute and the two Corliss engines running, a great deal more steam is obtained than is needed by the low-pressure turbine, even when running at its full load of 1000 kilowatts. This, then, makes the interesting combination of a low-pressure turbine without a governor running on a system of fixed back pressure and excess steam, which virtually amounts to no control on the turbine other than the throttle; i.e., the turbine carries a steady load as long as there is an excess supply of steam.

Gas Engines and Engineers

By F. L. Johnson

One day not long ago a friend, who had spent a great deal of time during the past few years attempting to design a noiseless gas engine, called to explain why more or less noise was necessary in the operation of a gas engine. Just as he had made it plain (to himself, if not to me) that the valve cams, gears and the toadstool-headed valves were of necessity more noisy in their action when used on a gas engine than when employed in the same way on a steam engine, my young friend Sawyer was shown into the room. Introductions followed, and the conversation was resumed:

"It has been found," said the designer, "that machinists and 'handy men' make much better gas-engine operators than regular steam engineers."

Sawyer, who has a settled conviction that it is a steam engineer's business to know more about the theory and practice of operating moving machinery than anyone else, at once became interested and asked for an explanation.

To make his point clear, the designer said:

"The machinist's one real advantage over the steam engineer is that he does not know how to run a steam engine, and because of his ignorance of the steam engine or of any type of engine he will naturally be more inclined to accept advice and instruction.

"Steam engineers expect engines to run quietly. Machinists do not know whether they should be noisy or not, and the usual noises which accompany gas-engine operation do not annoy him. Not expecting any particular sounds, he accepts the noises as he finds them as a matter of course and attempts no adjustments until he knows what to adjust and why it needs adjustment."

"In other words," broke in Sawyer, "the machinist runner handles a gas engine just as he does a lathe, a planer or a countershaft. He oils the convenient parts in the morning and the rest never. The countershaft gets attention when it squeaks and he runs the machine until something fails. Then he reports to the foreman and a mechanic is called in to fix things.

"I have never known an engineer who would not give an engine a chance to prove what it could do before starting in to make changes, and I do not believe one would treat a gas engine differently from what he would a steam engine. Of course, he does not like the everlasting clatter of cams and gears, because he has known these things to operate noiselessly in other places and does not understand why they need to be noisy here."

As the designer saw that my young friend was getting in earnest, he said, in a conciliatory manner:

"If the steam engineer will not demand of the gas engine that which it cannot give, and will leave all adjustments alone until he understands what the effects of making them will be, he will be able to hold his own against all comers."

Soft words and superior smiles in this case did not produce the desired effect, and my friend Sawyer, trying to conceal as much as possible his earnestness, said:

"I was present at a meeting of mechanical engineers where the alleged unfitness of the steam engineer successfully to operate suction producers and gas engines was dilated upon and the present and prospective owner gravely cautioned against employing an attendant whose previous condition of servitude had even in the most remote relation been connected with the operation of a steam engine. And I wish to say that I know that the steam engineer will have little or no difficulty in demonstrating his fitness for the work of operating gas engines and producers should any of your superior class of libelers ever succeed in designing a machine of nearly enough correct thermal and mechanical principles to be operated by anybody, not to mention the intelligent teamster taken from his seat on the wagon box, or the laborer divorced from the dirt pile and its attendant push buggy.

"Your remarks remind me of the time when a whole lot of callow electrical engineers condemned the Corliss engine as unfit for driving electrical generators because of the impossibility of satisfactory speed regulation. Most of these men have lived to see most of the electric current used for power and light come from generators driven by Corliss engines. It is the same class of intellectuals who today demand that a gas-engine operator shall be different from the steam engineer. Just how you want him different you do not say, but you leave it to be inferred that those characteristics which are the making of the successful steam engineer are handicaps on the other.

"It is perhaps possible that in the course of evolution from some of the masses of cast iron, steel and brass assembled by the cut-and-try process, with inaccessible moving parts misfitted by unskilled labor and mis-named engines, a machine will be produced that, like the brook, will go on forever, requiring little or no skilled attention and no mental effort on the part of the operator. The steam engineer whose trade it is to operate and care for moving machinery will be found the most successful in overcoming the difficulties of gas-engine operation and maintenance."

Inaccuracies of Indicator Diagrams

Distortion of Pencil Motion Due to Inertia, Pressure Lag or Inaccuracies in Mechanism and Spring. Calibration of Indicator Diagrams

BY JULIAN C. SMALLWOOD*

Drum-motion distortion has been discussed in a previous article, and it has been observed that the errors inherent to the indicator emanate from the untruth of its drum motion and from the faultiness of its straight-line mechanism and spring. The former causes inaccuracy in the abscissas and the latter in the ordinates of the diagram. There is still another source of error in the abscissas, namely, the imperfection of the mechanism reducing the motion of the engine crosshead, but this is external to the indicator.

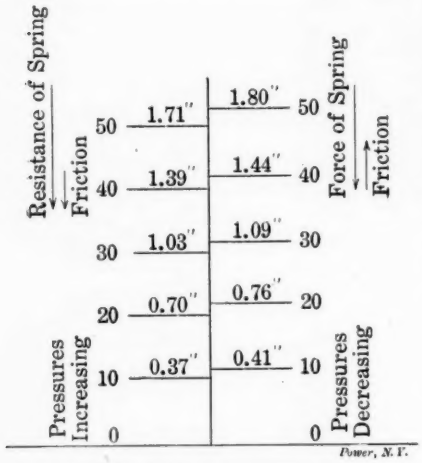


FIG. 1. CALIBRATION OF A 30-POUND SPRING

Distortion of Pencil Motion

Analysis of the pencil motion indicates that its distortion may be due to any or all of four causes: First, when applied to high-speed engines, the inertia of the indicator piston and attached linkage causes it to travel beyond its normal position. This results in a peaked admission line and a wavy expansion curve. Second, under the same conditions, the pressure in the indicator cylinder lags behind that operating on the piston of the engine because of the inability of the steam immediately to traverse the passages to the indicator. The error resulting is most considerable at about mid-stroke where the velocity of the reciprocating parts of the engine is greatest. The general effect is to increase the area of the diagram, cutoff and compression being represented later than they actually occur. Third, the mechanism actuating the pencil may incorrectly magnify the piston motion, and, fourth, the indicator spring almost invariably fails to exemplify the principle upon which its truth depends, that the contraction or extension of the spring is proportional to the force causing it.

Inertia—Of these four possibilities of error the first is troublesome only at high piston speeds. It may be obviated by the use of special indicators or by using stiff springs. Concerning the ordinary types, Professor Reynolds** has pointed out that the effect of inertia of the indicator piston and the attached moving parts can be expressed by two equations, one of which gives the probable distortion in per cent. during one cycle of the mechanism, and the other gives the number of oscillations of the pencil arm during that cycle. The same authority states that the former should be kept within 1 per cent. and the latter within the number 30. Using these figures the following values may be obtained from his equations:

$$s = \frac{0.00563\, W R^2}{a\, r}$$

and

$$s = \frac{0.0252\, W}{a\, r\, R^2},$$

where

s = Spring scale;
R = Revolutions per minute,
a = Area of indicator piston in square inches,
r = Ratio of piston to pencil motion,
W = Sum of the products of the weights in pounds of the separate moving parts and the squares of the ratios of such parts' motions to that of the indicator piston, respectively.

These equations may be reduced for any particular indicator to the form,

$$s = K R^2 \quad \text{and} \quad s = \frac{K'}{R^2},$$

in which K and K' are the constants combined. The greatest value of s resulting from their solution will give the lowest spring scale to be used for a given number of revolutions per minute.

Pressure Lag—The second cause of distortion of the pressure line, named above, cannot well be avoided at high speeds, nor can the resulting error be easily corrected. The disturbance is aggravated by long or tortuous pipe connections and may be considerable on this account even at low piston speeds. A comparison of diagrams taken with long and short connections shows that such piping should always be as short and direct as possible. The consequent error in mean effective pressure may be as high as 25 per cent.

Mechanism and Spring—Of the remaining sources of inaccuracy in the diagram's ordinates, that due to faulty pencil motion is in good indicators so small as to be unmeasurable. But the untruth of the spring not only may be very marked in a particular specimen, but may change with its use and age. Professor Carpenter, in a paper† discussing a lengthy series of calibration tests upon indicator springs, states that their "errors are of such magnitude that they cannot in general be neglected." Because of this fact it is the chief purpose of this article to tell how indicator springs may be tested and calibrated. It will be noted in the following that the corrections provide for error of the pencil linkage as well as of the spring.

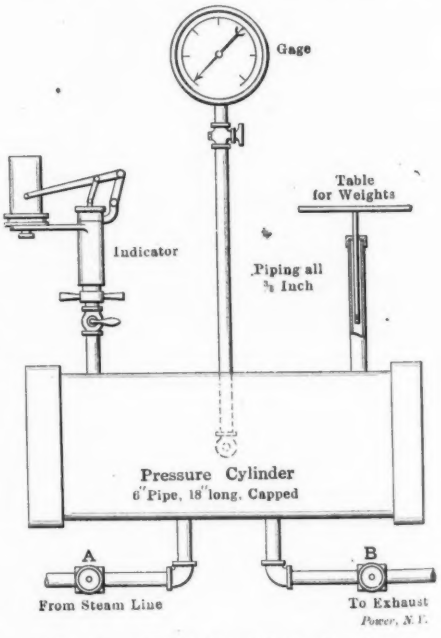


FIG. 2. TESTING BY STEAM PRESSURE

Calibration of Indicator Springs

It is first necessary to apply known pressures to an indicator which is fitted with the spring to be tested. Horizontal

*Instructor in mechanical engineering at the University of Pennsylvania.

**_Proceedings_, Institution of C. E., Volume LXXXIII.

†_Transactions_, A. S. M. E., Volume 15, page 454.

lines should then be drawn on a card to correspond to these pressures. The vertical distances between the separate lines and the bottom one may now be used to obtain a value of the actual spring scale. Referring to Fig. 1, five horizontals corresponding to pressures of equal increments are shown on the left, the pressure increasing. On the right the same is shown with the pressure decreasing. It will be noted that these lines do not coincide. The reason for this is that the friction between the piston and the cylinder walls and in the moving parts aids the resistance of the spring when the pressure is rising, but acts against it when falling, as is represented by the arrows. The conclusion will therefore be reached that to calibrate accurately an indicator spring, steam pressure should be used so as to reproduce exactly the conditions of friction, temperature, etc., met with in practice. This, however, is not always convenient and, when it is not, pressure may be applied mechanically to obtain a reasonably accurate calibration.

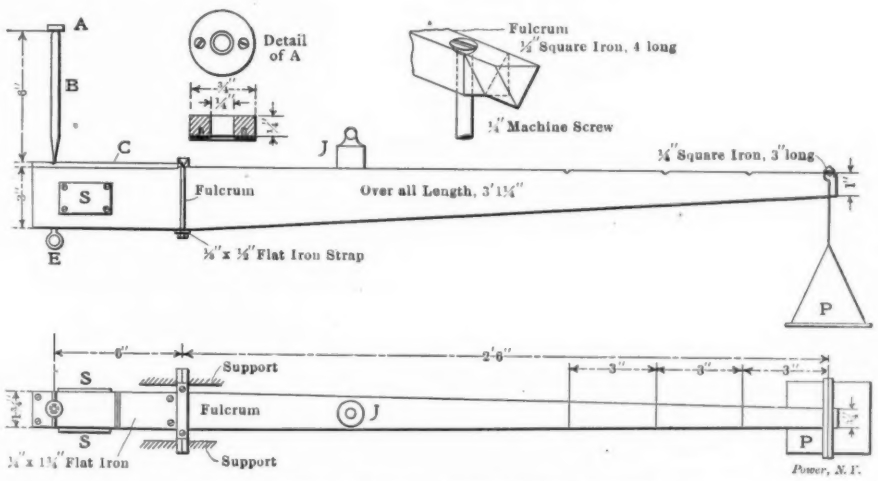


FIG. 3. LEVER TO APPLY MECHANICAL PRESSURE

Steam Pressure—Fig. 2 shows an apparatus for obtaining steam pressure of any desired amount up to that of the line. The drawing will be readily understood when it is explained that by adjusting the valves *A* and *B* the pressure is varied, and that the "table" is for the purpose of measuring it. An accurate gage would serve the purpose as well, but because of the unreliability of gages, this device is preferable. The table is of known weight and is integral with a rod which terminates in a plunger of small cross-section. The steam pressure within the cylinder may be measured by balancing it with standard weights placed on the table.

Mechanical Pressure—For the purpose of applying mechanical pressure to the indicator piston, the author suggests the simple lever shown in Fig. 3. This is of oak, with metal strips *S* screwed to the short arm of such weight as to maintain equilibrium in the position shown. A weight equal to that of *A* and *B* may be hung at *E* when balancing. The detail of the piece *A* will be noted. It is a piece of rubber which fits into the lower side of the piston, and is backed by a special washer fastened to it. The rod *B* is made of ⅜-inch round iron rounded at one end and filed to a knife edge at the other. The purpose of the combination is to transmit the load from a precise lever arm uniformly to the piston. In the position shown in Fig. 3, a one-pound weight on the weight pan *P* will effect a load of five pounds on the piston, which is equivalent to a steam pressure of ten pounds to the square inch, as the area of the ordinary indicator piston is one-half of one square inch. Thus, with 10 one-pound weights a 50-pound spring may be tested to 100 pounds. To test a lighter spring the weight pan may be placed nearer the fulcrum with a consequent reduction of force at the piston, the jockey weight *J* being employed to compensate for this change of position of the pan.

To test a 100-pound spring, the piece *B* may be placed at *C*. The whole apparatus may be set on a table when in use, and the indicator supported by screwing it to a tee which in turn may be held by a vise or other support. If desired low-pressure steam may be introduced into this tee so as to make the conditions of temperature friction, etc., more nearly those obtained in practice.

In the series of tests performed under the direction of Professor Carpenter, it appeared that a calibration of indicator springs tested cold resulted in an average spring scale 3.6 per cent. less than that obtained when tested hot. Professor Carpenter further states that by reducing the spring scale determined with the spring cold, by this per cent., an error of not more than 1 per cent. may be expected.

Whichever apparatus for testing is used the results are to be applied similarly to calibrate the spring. For this purpose any of the following three methods may be selected, depending upon the degree of accuracy desired.

Methods of Calibration

Referring first to Fig. 1, the figures placed on the horizontal lines give the distances of such lines from the bottom one or zero. Obviously, the distance between two lines corresponding to the same pressure represents double the value of the friction of the moving parts in the position corresponding to this pressure. It will be seen that to apply these results correctly it would be necessary to alter the ordinate of each point on the diagram and to construct an entirely new one. This, however, is so cumbersome a process as to be out of the question, especially as a single calibrated value of the spring scale combining those of the ascending and descending scales usually gives very acceptable results.

Extreme Values—To obtain a rough approximation of this combined scale, the highest ordinate of each set of lines, Fig. 1, may be divided into its corresponding pressure and the two averaged. Thus in the example cited,

$$\left(\frac{50}{1.71}+\frac{50}{1.80}\right)\div 2 = 28.5.$$

This is a crude result and has this disadvantage, that it is impossible to tell its limiting degree of accuracy or whether its error is positive or negative. The method has this merit, however, that if one of the scale divisions of a gage is known to be correct, then by its aid the above determination may be quickly and conveniently made. For example, suppose a gage has been compared with a known boiler pressure of 50 pounds and its error determined at this pressure. If now a simple slide-valve engine with indicator connections is accessible, it may be used instead of the apparatus in Fig. 2. To do this the indicator cock should have fastened to it a tee, one branch of which leads to the indicator fitted with the spring to be tested and the other to the gage. If, now, the crank of the engine is put on dead center so that it will not start, the main valve and one of the cylinder drain valves may take the place of valves *A* and *B* in Fig. 2. The steam is first allowed to flow through the drain from the main and then the lower valve slowly closed until the gage registers 50 pounds. A line may then be drawn to give the ascending scale. The drain should now be closed to raise the pressure above 50 pounds, and then cautiously opened until it has decreased to this amount to obtain the descending scale.

Graphic—A close approximation to the actual spring scale may be obtained by plotting the results in the form of two curves, as shown in Fig. 4, pressures as abscissas and hights of lines as ordinates.

A straight line is passed through each curve, so inclined as to deviate from it as little as possible. If, now, the tangents of the angles made by these straight lines with the vertical axis are separately multiplied by the ratio of the scales of abscissas to ordinates of the curves, the values resulting will be the new ascending and descending spring scales. From Fig. 4 these values are,

$$\frac{10}{0.2} \times 0.589 = 29.45$$

and

$$\frac{10}{0.2} \times 0.577 = 28.85,$$

the mean of which is 29.15.

Inspection of these straight lines shows that neither of them passes through the origin of coördinates, and it may be said generally that this is a characteristic of such calibration curves. The cause of it is lost motion in the pencil linkage, and friction. If these did not exist, a straight line passing through the origin and parallel to the one found would result.

Least Squares—The graphic method depends upon estimating the "most probable" straight line represented by the points plotted and is necessarily a guess. But it may be expressed algebraically, and from the equation a value of the spring scale may be found by the method of least squares. By this process the best obtainable result will ensue. No attempt will be made here to explain the theory of the method; only its particular application to the subject under consideration is given. The equation of the calibration line is,

$$p = h\,s + c,$$

from which

$$ph = h^2\,s + ch,$$

where

p = Pressure corresponding to the hight of the ordinate h,
s = Spring scale and
c = Unknown constant.

The observations shown in Fig. 1 are substituted in these equations thus, to obtain the descending scale:

$$\begin{aligned} p &= hs + c \\ 10 &= 0.41s + c \\ 20 &= 0.76s + c \\ 30 &= 1.09s + c \\ 40 &= 1.44s + c \\ 50 &= 1.80s + c \\ \hline 150 &= 5.50s + 5c \end{aligned}$$

$$\begin{aligned} ph &= h^2s + hc \\ 4.1 &= 0.1681s + 0.41c \\ 15.2 &= 0.5776s + 0.76c \\ 32.7 &= 1.1881s + 1.09c \\ 57.6 &= 2.0736s + 1.44c \\ 90.0 &= 3.2400s + 1.80c \\ \hline 199.6 &= 7.2474s + 5.50c \end{aligned}$$

The last equation of each series is the sum of the equations preceding it, and dividing these resulting equations respectively by the coefficients of c contained in them, the following results are obtained:

$$30 = 1.1s + c$$

$$36.29 = 1.3177s + c.$$

From the solution of the two equations:

$$s = \frac{6.29}{0.2177} = 28.89$$

pounds for the descending scale, and similarly for the ascending scale, $s = 29.33$ pounds per inch. The mean of these values is 29.11.

To compare the results obtained by the three different methods, the following is instructive:

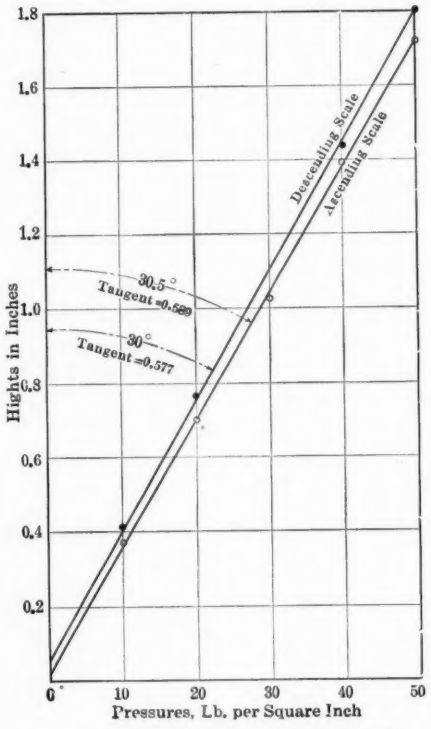


FIG. 4. CALIBRATION CURVES FOR A 30-POUND SPRING

Method.	Ascending Scale.	Descend'g Scale.	Mean.
Extreme values..	29.25	27.8	28.5
Graphic.....	29.45	28.85	29.15
Least squares....	29.33	28.89	29.11

An examination of these results shows that there is 0.13 per cent. of error involved in the graphic method, assuming the value obtained by least squares as correct. The accuracy of this method is dependent upon that of the estimation of the straight lines and the limitations common to graphic measurements. Referring to the first set of values tabulated, that for the ascending scale is fairly close; but, because that for the descending scale is low, the mean is 2 per cent. in error. The explanation for these disparities is found on the calibration curves. If the points whose coördinates have been used in the calculation lay on the lines, and if the ordinates of these points were corrected by subtracting from them the intercepts of the lines with the vertical axis, respectively, the results would be correct. It is impracticable to determine these intercepts, however, without actually drawing the lines. The error caused by neglecting them obviously is less appreciable when the values of the ordinates are high, and this is the reason why the hights at the greatest pressures are used in the calculation.

In conclusion, it may be well to lay stress upon the fact that the accuracy of calibration is primarily dependent upon the truth of the pressure-measuring device. If weights are used, as suggested, their values must be definitely known, as any error will be magnified. The conditions of practice, as to lubrication, etc., must be as far as possible duplicated. If the method of least squares is used the calculations must be performed with precision to the last decimal, as will be apparent from the sample calculations in this article. In any case, the more determinations made the closer will be the result. With reasonable care in making observations, distortion of the pressure line may be compensated for within 1 per cent. of error.

Motive Power Equipment for Textile Establishments

In an informal talk before the Southwick Textile Club at Lowell, Mass., recently, Charles G. Burleigh referred to some of the blunders made in the motive equipment of textile mills and pointed out the advantages of alternating-current motors and steam turbines for that class of work. To begin with, he strongly urged leaving the engineering details of the power equipment to the manufacturer of the apparatus, selecting a manufacturer who has had creditable experience in this particular class of work. This advice was based on the hypothesis that no reputable manufacturer can afford to recommend anything else than the most satisfactory types and sizes of machine.

Direct-current generators and motors are less desirable than alternating-current machines, he said, because of the limited voltage, which militates against a central power plant for a large group of factory buildings, and the commutators and brushes of the motors, which are undesirable from the insurance point of view and are much more expensive and troublesome to maintain than the simpler induction motor. The gradual increase in the speed of a direct-current motor, due to the heating of the field-magnet winding and consequent decrease in field ex-

citation during each day's run, was also cited as a serious disadvantage. In order to avoid overspeeding a textile machine after the field winding of the motor becomes warm, he explained, it must be operated at less than its rate of maximum production while the motor is warming up.

Mr. Burleigh then reviewed briefly the advantages of electric drive over distributed shafting and belting, flexibility of control being the chief benefit.

He advocated the use of the steam turbine for the prime mover in the power house on the score of reliability, economy in first cost, operating expense and floor space, absence of oil in the exhaust steam and the feasibility of taking steam out from the intermediate stages for dyeing, bleaching, etc. He favored the Curtis type of turbine because it is obtainable in either the vertical or the horizontal form, the speed rate, in revolutions, is lower than that of other types, the distance between bearings is shorter, there is no appreciable end thrust in the horizontal form and the clearances are relatively large for a given economy.

The Conservation of Our Water Powers*

By John F. Vaughan

There are two subjects we have heard a great deal about lately: (1) The combining of corporate interests, and (2) The conservation of our natural resources.

Probably the most important example of corporate combination has been in the merging of steam railroads into a few comprehensive systems. This has been followed by a more or less successful movement to consolidate lighter electric railroads, with a tendency further to combine these with the older steam roads. And now in the development of high-tension electrical transmission we have the physical means of combining widely scattered water powers, and in the adoption of electricity as a distributing medium a strong incentive for the combination of interests of all three of these classes: Heavy and light railroads and water powers.

As a matter of fact the combining of steam and electric railroads has already begun, and now there is scarcely a steam road in the country which is not seriously considering electrification of at least a part of its system, and there are many which are either acquiring or are actually developing water-power privileges to furnish them with motive power. Here, then, among the railroads we find a common interest in the economic development of our water powers.

The second subject—that of the conservation of our natural resources—in its bearing on the welfare of the country is of general interest to railroad men, and as far as it affects the regulation of stream flow is of especial importance to them wherever water power is available. As traffic grows, as train weights and speeds increase, and fuel becomes more scarce and inaccessible, water must be more and more depended upon for power.

The present rate of deforestation, increased as it is by fires set by passing locomotives, in its effect on the reliability of water powers, and on the increase of damage by flood, demands serious consideration.

Water-power Resources and Development

Now what are our water-power resources and to what extent have they been developed? The fullest source of information on the extent of the country's water-power resources is in the admirable hydrographic work of the United States Government, but unfortunately this is still insufficient for making more than approximate figures, and while the records of stream flow are fairly comprehensive, comparatively little is known of the possibilities of storage.

The following conservative estimate of the water-power resources of the country has been published recently by Mr. Van Schon. He gives the amount of water power already developed as 2,050,000 horsepower, and the available undeveloped power, without the help of storage, as 10,000,000 horsepower.

H. St. Clair Putnam, in his address before the recent conference called by the President at the White House, estimated the total unconserved power available in the streams of the United States considerably higher, i.e., 30,000,000 horsepower, which is equivalent to the total power of all kinds now installed in our land industries. He assumed that with storage and supplemental plants this may be increased to 150,000,000 horsepower, or five times the present total power of all kinds in use. Now, when we find the demand for power increasing at the same rate as our manufactures, mining output, product and railroad earnings—that is, doubling every ten years since 1870—we have evidence enough of the increasing value of water powers. Right in New England, yes, even in Massachusetts, where Dr. Steinmetz has made the surprising statement that there is more water power going to waste than is contained in the whole of Niagara, we have plenty of opportunity for improvement.

Requirements for Successful Development

Now, what are the requirements for the successful development, and why has it not been more rapid? The reasons have been partly lack of available market for the power, partly the excessive cost of development and partly the difficulty of stream regulation. With the old type of water wheel and costly mechanical transmission, it was necessary to use the power at the wheel, and then with perhaps only a part of the fall available without elaborate and costly canal systems. The more recent turbine and yet newer impulse wheel, although utilizing the full head of the fall, have been still hampered by the necessity for using the power near the fall. But now with the growth of electrical transmission not only can remote markets be reached, but powers formerly inaccessible may be developed and operated singly or in groups, for better economy and efficiency. Thus the differing characteristics of power markets may be largely equalized and better service and larger returns obtained from the investment.

The best examples of the consolidation of water powers are in the California system, where plants scattered through the mountain cañons feed into common networks of transmission lines, serving large territories with power for railway and industrial plants, pumping, etc., and in some cases delivering the discharged water for irrigation; and the best example of combination of markets is in the great systems of Niagara, delivering power over hundreds of miles of lines for an infinite variety of uses.

We have good examples of the use of water power by railroads in the plans of the Chicago, Milwaukee & St. Paul, which is already making the initial development of some 200,000 horsepower available in 35 miles of the St. Joe river, for operating its trains electrically over the Great Divide, in the electrification of the Cascade tunnel of the Great Northern railroad, in the conversion of the Harriman lines around San Francisco, in the equipping of the New York Central for operation by Niagara power, and in many light electric railroads all over the country.

Requirements for Economical Use

Let us see what the principal requirements for the economical use of our water powers are:

Stream flow should be controlled so as to get the maximum energy out of the stream as a whole, and not merely for the benefit of certain isolated plants. For instance, no one plant with storage should be allowed to hold back the natural flow when required by down-stream users who have no storage to draw on, or to flood them with excess water when detrimental to their interests.

The storage facilities of the drainage basin should be developed as far as practicable for steadying the natural flow of the river, increasing the capacities of the various developments and reducing trouble and damage from floods. For instance, since any development over and above the capacity of the minimum dry-season flow of the stream must be relayed

*A paper read before the New England Street Railway Club.

by other power, or the excess sold as cheaper secondary power subject to interruption, even an average stream will waste more power than it can use, and a torrential stream, which may flow in flood over one hundred times its low flow, will give up only a few per cent. of its total energy. It is evident that expensive storage cannot be accomplished without the coöperation of the power users and an equitable sharing of the expense.

A Good Example of Stream Control

Perhaps the best example we have of stream control is in the Merrimac river, where through the coöperation of milling interests at Lowell, later joined by Lawrence mills which shared the expense, the storage facilities at Winnepesaukee, Squam and other lakes were developed and a comprehensive plan of stream measurement and control established, and today the use of water at Lowell, Lawrence and Manchester is so closely watched and regulated that during dry months practically no water is wasted, and during last summer's drought, although the various small tributary streams furnished practically no supply, the flow of the river held up remarkably well.

As far as possible various plants should be tied together to feed into a common network of distributing lines so as to utilize the stream flow to its best advantage, to equalize local peaks and irregularities of load, to reduce surplus investment in spare and breakdown capacity, to cut down distribution costs, and to improve the regulation of the system. By such combination the number of units in each plant may be reduced, hydraulic and electric designs simplified, complication of switching and control cut down, and a corresponding saving made in fixed charges and operating costs. In this way many communities may be served which otherwise could not support the burden of individual development.

Arrangement with other power producers should be considered for the interchange of surplus power, especially where the peak demands are not simultaneous. For instance, an agreement between a lighting company and a coal mine in Pennsylvania for the interchange of power up to 2500 kilowatts, where the mine shuts down before the peak of the lighting load, now enables each to reduce its fixed charges on spare equipment and to improve its load factor.

Utilizing Surplus Power

Surplus power during light demand, or surplus water, should be utilized for industrial purposes, such as pumping, electrochemical or metallurgical processes. For example, the electrical recovery of peat from wet bogs and the manufacturing of fertilizers and certain other products of modern chemistry from nitrogen recovered from the atmosphere are not wholly visionary, nor is it necessarily crazy to use surplus flow to pump water into reservoirs above the natural water levels for use during dry periods or excessive loads. In certain localities surplus or discharged water should be utilized for water supplies or irrigation. Groups of plants now on the old series canal systems, or plants otherwise inefficient in the use of water, should be redeveloped.

Robert E. Horton recently pointed out, in an address before the Schenectady branch of the American Institute of Electrical Engineers, a number of opportunities of this kind among our eastern streams; as, for instance, at Holyoke, where there are about fifty mills taking water from a series of canals at three different elevations; at Cohoes, at the junction of the Mohawk and the Hudson, where about thirty mills draw on five canal levels. There are also many cases where for the same reasons the available fall is divided up by series of low dams, each with its own wheels dependent on the dams above for water and liable to backwater during flood.

Obstacles to be Overcome

There are, of course, many obstacles to overcome before our streams can be properly controlled and their power utilized to best advantage; legal tangles to straighten out, franchise restrictions to modify, dams to build and to rebuild, and innumerable physical and operating details to work out. But water is a permanent asset which is neither burned up like fuel nor carted off like our mineral resources, but returns with every fog and rain storm to be used again.

In the interdependence of the territories embraced by the various watersheds our interests in this asset become national, warranting federal control, or at least State action under federal supervision, and already we have in the hydraulic work of the New York State Water Supply Commission, established under the Fuller bill, a substantial advance made in the study of the storage possibilities and in its effect on present and future water powers of the State, and in the National Conservation Commission, appointed by the President, a definite establishment of Government policy. Both of these commissions recognize that the conservation of our water supply is of sufficient importance to call for comprehensive plans of water storage and stream control, and that the Government should eventually distribute the cost of such improvements among all interests in proportion to the benefits received.

On this basis, then, the water-power interests will be required to carry only a burden in proportion to the benefits they receive; and such a policy will not only enable individual enterprises to develop their resources to best advantage, but will give their properties a more definite and permanent value.

In this general movement toward stream betterment there is a definite beginning of a more economic use of our water-power resources, and in the growth of electrical transmission a means of reducing both first cost and operating expense. And from whatever point we view the matter we have plenty of reasons for encouraging the conservation work already begun by the Government and, in addition, plenty of opportunity for studying the improvement of our existing powers and the development of new.

Comparative Tests of Coal

By Peter H. Bullock

At present there is a good deal of uncertainty about the quality of coal delivered to customers in the East, and this applies to all coals regardless of the names they may be sold under. Coal has been sold and delivered under a hyphenated name that carried only a suggestion as to quality, and that suggestion would only be founded on the fact that either before or after the hyphen there would be a familiar name. John Smith-Pocahontas, or Georges-Paul Creek might be very good or very poor coal. Some buyers have adopted the B.t.u. system, the price to be a sliding scale determined by the analyses of samples of the coal. This seems to be fair, but it is one thing to know how many B.t.u. there are in any coal, and quite another to catch all the B.t.u. in the furnace.

It would appear that the only information needed by the purchaser is, how much water can be evaporated under regular conditions with a dollar's worth of coal? The exactness of chemical analysis is not to be doubted, but it is also certain that a fireman will sometimes do better with coal that does not show up the best when so tested.

It will undoubtedly be admitted that better tests can be made in small plants where all the coal and water used can be weighed and the steam generated applied to the usual and regular service. In large plants where there are many boilers and frequent changes of men, it is practically out of the question to deal with the whole plant and get satisfactory results. Of course it is possible to cut out the feed pipe of one boiler and weigh the coal and water fed to it in any given time, but the expense and the uncertainties that attend such a test make it advisable to provide a simple apparatus for this especial purpose. Accordingly, the writer has designed and put into operation a small plant for comparative tests of all coal purchased. It will be noted that the word comparative is used, for the simple apparatus installed leaves out many things that are taken in standard tests. Not but what these data are valuable, but because they are not necessary in a case where the efficiency of apparatus is not a question, and it is only necessary to determine how much water

one dollar's worth of A, B or C's coal will evaporate in a furnace and under precisely the same conditions.

Testing Apparatus

The testing apparatus is simply a plain return-tubular boiler 16 inches in diameter and 4 feet long, with thirty 1¼-inch tubes 3 feet long. It is set in firebrick and has a dumping grate of 1½ square feet area. It has no fittings except a gage glass, and is fed through a funnel from a tank setting high enough for the purpose. The outlet pipe is short, open to the air and large enough to carry off all the steam the boiler can make. The stack is 8 inches in diameter and is used only to carry away the smoke, the necessary draft being furnished by a fan and engine run by steam from another source, so that the intensity of the draft can be maintained at any desirable point, and is measured by a U-tube at the ashpit.

When a test of fuel is to be made, light wood is burned until steam is flowing freely from the pipe. The hight of water in the gage glass is then noted and 4 pounds of fine wood is put into the furnace to start the coal fire. Then 100 pounds of coal is burned, and all the water that possibly can be is evaporated. When the coal is all burned the hight of water in the gage is left exactly the same as at the beginning of the test. It is then known how much coal has been burned and how much water evaporated.

The tubes, furnace and ashpit are now cleaned and all the refuse weighed, giving the percentage of combustible. To get the moisture in the coal 6¼ pounds, or 100 ounces, is put into a shallow baking pan which is placed in a flue where there is a current of air at 120 degrees and is left there for five hours; when it is again weighed and the loss noted. There may be some objection to this method, for it may be claimed that in order to get all the moisture out of the coal, the temperature should be 212 degrees. This treatment, however, leaves the coal practically dry, is as fair for one man's coal as another's, and the higher temperatures would in some cases carry off volatile gases that might better be left, as they have a fuel value which the seller is entitled to have the benefit of. The temperature of the water used is taken. The price of the coal is known, the equivalent between any temperature and 212 degrees is known, and it is then a simple matter to obtain the comparative amounts of water that the coal from A, B or C has evaporated in the same apparatus and under exactly the same conditions. The data can be reduced to either of two units: cost of evaporating 1000 pounds of water, or how much water will one dollar's worth of coal evaporate? The comparative economy is the same whichever unit is used.

A Question of Moisture

There is a question in regard to the moisture in the coal at the time of the test and the moisture in the coal at the time it was weighed for shipment. The bills are made out at the time of shipment, and if the coal is wet when weighed the water in the coal is paid for. The sample tested may have become partly dry so that the actual amount of coal burned would be that much more than would be represented in the bill. On the other hand if the coal was dry when weighed and it had been exposed to wet weather, the amount of fuel in the test would be less by an amount equal to the weight of water added. Recently a car was received that had been three weeks in transit and showed 9 per cent. of moisture in the 120-degree five-hour test. If the facts as to moisture could be settled when the coal was weighed and billed, it would be easy enough to make the proper allowance for any wetting or drying it got between the weighing and the testing points. This seems to be practically out of the question, and, of course, every dealer would claim that the coal was dry when weighed and that he ought to have the benefit of the doubt in the test.

In a trial test under standard conditions the quality of the steam as to dryness has to be taken into consideration, but in this apparatus the coal is burned to the best of our ability, clean water is fed into the boiler and to all appearances nothing but good, honest steam goes out of the pipe. At any rate it is the same as to conditions at all times, as an even draft is maintained and about as much coal burned per square foot of grate per hour as in regular work in the fire room.

The writer has uniformly found a greater per cent. of ash than the sellers want to admit. This may be due to the fact that the tubes, setting and furnace are brushed clean after each test and everything is weighed as ash, for it all comes from the coal and certainly is not combustible. In tests under commercial conditions, no doubt considerable ash and dust escape that properly belong in the ash column.

Tests of Sample Lots

In samples Nos. 1 and 2 in the tests following the coal was the same, only in No. 2 sample it had been exposed out of doors to the sun and rain for six months in an open box. For samples Nos. 3 and 4 coal was taken from the same car, only No. 4 had been kept in a closed box indoors for six months. The last two samples tested substantially the same, while sample No. 2 showed a loss from exposure. It is improbable, however, that coal in large, deep piles will lose its heat value to any great extent, although the exposed surface of a large pile for a few inches in depth might readily do so.

Recently the writer made a test of some coal and put another similar quantity under water for a future test, the first sample being left under water one day so that it would be perfectly saturated, as, of course, the other would be when taken out for trial. For an even comparison this method would appear to be better than to make figured corrections for moisture contained; besides, it keeps the local conditions of firing the same in both cases.

In the test records the unit of comparison is the cost of evaporating 1000 pounds of water into steam at zero pressure, and the formula is:

$$\frac{1000 \times \textit{Pounds of coal burned} \times \textit{Price per ton}}{\textit{Pounds of water used} \times \textit{Factor of evaporation} \times \textit{Pounds per ton}}$$

Samples Nos. 1 and 2 were taken from the same car and each weighed 100 pounds with 7 per cent. moisture. Sample No. 1 was tested at once and No. 2 six months later after being exposed to the weather in an open box, so that at the time of the test it carried 12 per cent. of moisture. As the lots of coal when bought and weighed were the same, and the moisture at the time of testing different, the computations were made on dry coal in each case, so that instead of using 100 pounds as weighed, 93 pounds of dry coal was substituted, and the amount of water ascertained to be in the coal was added to the amount evaporated. No. 1 sample contained 11.5 per cent. of ash, and the cost to evaporate 1000 pounds of water was found to be:

$$\frac{1000 \times 93 \times \$4.40}{(706+7) \times 1157 \times 2240} = \$0.22.$$

Sample No. 2 contained 12 per cent. of ash and the cost was:

$$\frac{1000 \times 93 \times \$4.40}{(547+12) \times 1.17 \times 2240} = \$0.27.$$

Samples Nos. 3 and 4 each weighed 100 pounds and were taken from the same car. No. 3 was tested at once and No. 4 was put into a closed box and kept six months. Moisture was not tested in either case, and ash in both lots was 14½ per cent. To evaporate 1000 pounds of No. 3 cost

$$\frac{1000 \times 100 \times \$4.03}{685 \times 1.145 \times 2240} = \$0.229,$$

and of No. 4

$$\frac{1000 \times 100 \times \$4.03}{671 \times 1.179 \times 2240} = \$0.227.$$

At the time the tests of samples Nos. 1 and 2 per were made, the 12 per cent. of moisture seemed excessive, as 8 or 9 per cent. is usually considered about the limit. The writer has since made several tests for moisture and found that dry coal may absorb and carry up to 13½ per cent., but samples from large piles left under the eaves for several months seldom show over 4 or 5 per cent., even if saturated when unloaded. Can this excess moisture leave the coal either by evaporation or by seepage without carrying heat-giving qualities with it ? is a question the writer would like answered.

The Plunger Hydraulic Elevator

Practical Instructions in the Care and Management of the "Standard" Plunger Elevator, Illustrating the Essential Features to Look Out For

BY WILLIAM BAXTER, JR.

Whenever it is desired to take out the main valve of the Standard plunger elevator, it can be removed through the back end of the valve cylinder. Before it can be drawn out, however, the rack at the end that rotates the pinion of the pilot valve must be thrown out of gear. To do this all that is necessary is to remove the hood in front of the pilot valve, into which the rack runs, and then the shoe that holds the rack and pinion in mesh can also be removed and the rack can be pushed to one side so as to clear the teeth of the pinion. When this is done the valve can be drawn out of the back end of the valve cylinder without difficulty.

To remove the automatic stop valves the cylinder head must be removed, and also the bonnet under the center. The cranks that operate the automatic stop valves are fastened to the shafts on which the operating levers are mounted by means of caps, and the screws that hold these caps can be reached when the bonnet is removed. If the cap is taken off the crank can be pushed upward and can be drawn out, together with the valve, through the end of the valve cylinder; all of which can be readily understood upon examining the valve drawing, Fig. 283, shown in a previous article. The cranks are keyed to the shafts, to prevent them from turning, and in putting the valve back care must be taken that the key is returned to position and the screws tightened up as much as they were before, so that there may be no danger of working the parts loose thereafter.

Pilot Valve Removal and Adjustment

The pilot valve, body and all, can be removed by taking off the end hood the same as for throwing the rack out of gear, as explained above. When this hood is removed, the bolts that hold the pilot-valve body can be reached and taken out and then the valve can be removed, together with the shaft that carries the pinion and the cams that prevent too rapid reversal of the elevator motion. A side view of all these parts is given in Fig. 307, which is a vertical section. This drawing does not show the means by which the valve body is fastened to the end casting of the main valve body; these consist of lugs that spread out on each side of the shaft L'' at the top and bottom, opposite the bearings through which the shaft slides. A view of the valve body at right angles to Fig. 307 would show these lugs, on opposite sides of the parts E and F. To remove the valve alone, all that is necessary is to take off the connecting arm D and the lower cap C; then the valve can be drawn out through the lower end.

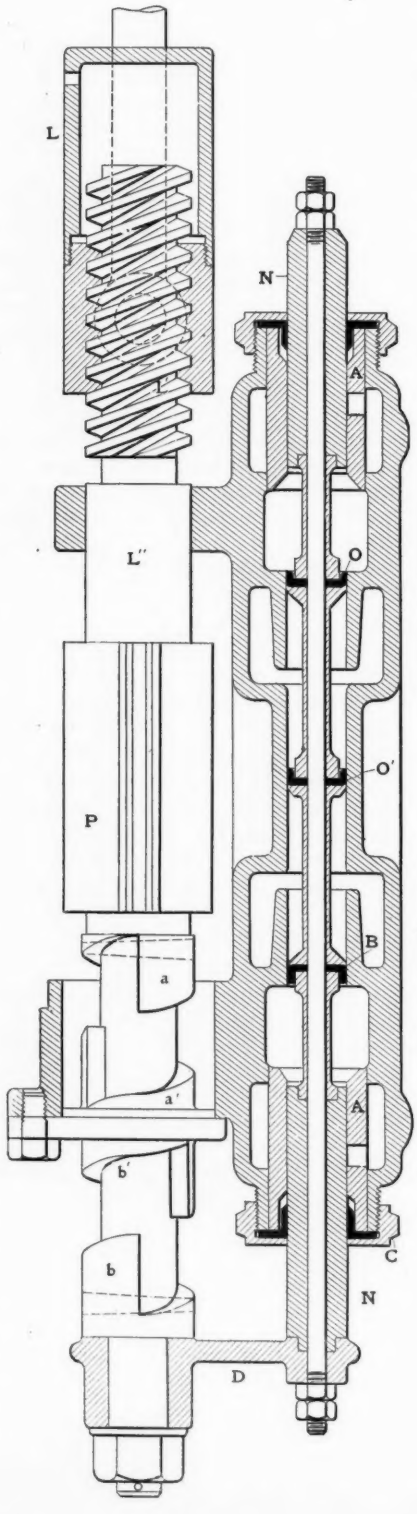


FIG. 307

Referring to Fig. 307 it can be seen that no provision is made for adjusting the position of the pilot-valve cup packings, nor for adjusting the cams a, b, a' and b'. Adjustment of the position of the cup packings would only serve to vary the lap of the valve, and such adjustment is not only not necessary but not advisable, because the manufacturers know better than anyone else what the adjustment should be and they make the valve of proper proportions. Increasing the depth of the cups will not have any effect on the lap of the valve, because they enter their seats back end first and make a joint after entering a certain distance, independent of the depth of the cup. Under certain conditions, if the edge of the cup projects beyond the end of the cylinder, water may force its way between it and the cylinder and thus leak through. This is not likely to occur, but as it may, it is wise to use cups of the proper depth, and no deeper. The cams require no adjustment, because all they are intended for is to prevent moving the lever any farther, in stopping, than it was moved in starting; and if once made of the proper dimensions to accomplish this result, they will always do so.

The only adjustment provided in the pilot valve is in the ports through the sleeves A, A' at the ends of the valve, and the similar adjustment on the side ports, which was fully explained in the article describing this apparatus. If in the course of time the water flowing through these port holes enlarges them so as to cause the main valve to close too rapidly in stopping, the proper adjustment can be obtained by running in the adjusting plugs a trifle. It may be found in making such changes that the car speeds up too fast in starting when the valve is partly opened in order to run at a slow speed. If this should be the case, the acceleration can be reduced by screwing in farther the plug opposite the port hole in the inner end of the sleeve A, and if after doing this the car does not get under headway fast enough when the valve is fully opened, the acceleration can be increased by drawing out one of the other adjusting plugs. In making these ad-

justments it should be remembered that a very small difference in the opening of the ports will make a decided difference in the rapidity with which the elevator will get under way; hence, the position of the plugs should be changed only a little at a time. In the type of valve shown in Fig. 283 the main valve is moved to the right to cause the elevator to start upward; it is also moved to the right to stop the elevator on downward trips. Therefore, if the flow of water through the ports of the top sleeve *A* is decreased, the effect will be to reduce the acceleration in starting on up trips, and to prolong the stopping on down trips. To stop going up and to start going down the main valve must be moved to the left; hence, if the adjusting plugs opposite the ports in the lower sleeve *A* are run in, the up stops and the downward starts will be made slower, and *vice versa*.

If the elevator is arranged so that the cylinder discharges into an open tank located on a level with the main valve, there will be no back pressure to force the water into the cylinder through the bypass connection, and the adjustment of the velocity of motion of the main valve must therefore be made so as to reduce the velocity enough to prevent jumping the plunger off the water in the cylinder when the car is brought from its maximum speed to a stop. If, however, the water in the cylinder is discharged into an elevated tank, or into a pressure tank, the valve is adjusted with reference to starting on the downward trips, so that the car may not move so rapidly as to produce an unpleasant sensation. Therefore, it will be seen that the adjustment of the plugs at the lower end of the pilot valve, opposite sleeve *A*, must be made with reference to the rapidity of stopping on the upward trips, with one method of piping, and with reference to starting on the downward trips with the other method.

The adjustment of the plugs opposite the sleeve *A* at the top of the pilot valve is made with reference to the rapidity of starting on the upward trips, and stopping on downward trips. There is little danger of starting too rapidly, because the water flowing into the cylinder has to lift the load, and it cannot very well get it under headway so rapidly as to produce an unpleasant sensation, unless the lifting capacity of the plunger is excessive, and the load in the car is light. In stopping on the downward trips, however, the reduction of speed can be so rapid as to greatly increase the tendency to buckle the plunger, hence the adjustment of the plugs at the top of the pilot valve should be made with reference to the rate of retardation of speed in stopping on the down trips, and this adjustment will be found satisfactory for the starting on upward trips.

In the valve shown in Fig. 282 the movement of the main valve is the reverse of that above explained, that is, the valve moves to the left to start on the upward trip, instead of to the right, hence the top adjusting plugs are used to do just what the bottom ones do in Fig. 283.

The Packings

All the packings used in the valves of the Standard plunger elevators are leather cups, as can be seen by looking at the various drawings we have presented. These packings are replaced in the same manner as in the elevators of other makes previously explained, and require no further explanation here. The stuffing box at the top of the plunger cylinder is packed either with hemp or any good soft packing, or with a specially constructed double cup leather packing. The cross-section of this packing is shown in Fig. 308. The packing is made in two parts, *A* and *B*, both of leather. These two parts are cut on one side so that they may be slipped over the plunger from the side, and they are placed in the stuffing box so

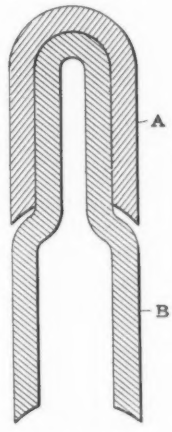


FIG. 308

that the joints are on opposite sides of the diameter.

To keep any hydraulic elevator in perfect running order it is necessary that all the packings be kept tight; if they are not, the car will not remain stationary when stopped at a floor, but will move gradually either up or down, according to where the leak is located. In plunger elevators, if the stuffing box at the top of the cylinder leaks the car will settle when standing at a floor. It is an easy matter to determine whether the cylinder stuffing box leaks or not, for if it does the water can be seen trickling over the top of the stuffing-box gland. If there is no leak at this point, then the trouble will be found in the main valve, which will permit water to flow through to the discharge pipe; hence, the packing in the piston that shuts off the discharge must be renewed. If the car creeps upward after being brought to a stop it indicates that the cup packing in the valve piston that closes the supply ports is leaky. Sometimes the elevator, after being brought to a standstill, creeps up a short distance and then creeps back, and continues this alternating motion indefinitely. This indicates that the pilot valve is defective, but as it is an occurrence that can take place with any type of hydraulic elevator it will not be explained here. In a future article this subject will be discussed in detail, by the aid of diagrams that will make the action perfectly clear.

In addition to keeping all the packings in good condition it is necessary that the running gear of the valves be not allowed to get out of adjustment. The rope that moves the pilot valve and those that operate the automatic stop valves must be examined frequently to see that they are in good condition and their fastenings tight, particularly as to the stop-valve ropes because these valves are safety devices.

With the Standard plunger-elevator system in which the discharge tank is closed and a pressure is maintained therein, it is necessary that the pressure be kept up to the proper point to obtain the best results. The pressure is required to cause the water to follow up the plunger when the valve is closed suddenly in making a stop on the up trips. If the pressure is permitted to drop the plunger may be drawn away from the water in the cylinder, with the results already explained. There is no danger of getting the pressure too high, as this is limited by the hight of the inverted goose neck provided for that purpose. It is not desirable, however, to permit the pressure to rise above the proper point because too much water will be forced out through the goose neck, and this will have to be replaced by water drawn from an outside source, which generally will be at a lower pressure; hence it will represent just so much power thrown away. It is also necessary that the supply of air in the discharge tank be well maintained; otherwise, the pressure will vary too much when water is drawn from the tank or discharged into it. Whenever the construction of the building permits, the pressure in the discharge tank is obtained by locating it at the proper elevation, as this is decidedly the best arrangement, as the pressure then cannot vary. With an elevated tank all that is necessary is to keep the water at the proper level so that the pipe running down to the cylinder may always be far enough below the surface not to draw in air.

At the University of Wisconsin, February 24, 25 and 26, one hundred and fifty city engineers, general managers of power and traction companies, contracting engineers, superintendents of water and light plants, mechanical and civil engineers and superintendents of highway construction organized the Engineering Society of Wisconsin. The officers elected were: President, F. E. Turneaure; vice-president, McClelland Dodge; trustees, B. F. Lyons, E. P. Worden, E. Gonzenbach and E. R. Banks.

Municipal Producer Gas Plant at Peru, Ind.

A Lighting and Power Installation Which Supplanted a Steam-Engine Plant and Has Shown an Appreciably Reduced Consumption

BY OSBORN MONNETT

Producer-gas power is being successfully used in the municipal plant at Peru, Ind., generating electricity for city pumping, street lighting, commercial lighting and power service. It is supplanting a steam plant which has been variously estimated as producing a brake horsepower-hour on from 5 to 15 pounds of coal and, to date, with light loads and uneconomical conditions, has succeeded in reducing the consumption to 1.6 pounds. The steam plant consists of high-speed engines driving 133-cycle belted alternators through a jack shaft. During the period of transition from steam to gas power it has been thought advisable to change to the more modern 60-cycle system; consequently, both plants must be kept in operation temporarily and for this reason it has not been possible to load the gas-power plant sufficiently to come within its guarantee of one pound of coal per horsepower-hour. At present the one unit installed, a view of which is given in Fig. 3, carries all of the street lighting, consisting of 160 series arcs, all of the pumping load and day power load, and half of the incandescent lighting. This necessitates running twenty-four hours per day.

The city pumping is done with two 2-stage Worthington centrifugal pumps, each driven by a 60-horsepower Western Electric induction motor. The pumps are located in a cement-lined water-tight pit, adjacent to the power plant, and are below the level of water in the wells from which the supply is obtained. Each pump has a capacity of 1,500,000 gallons in twenty-four hours, against the city pressure of 55 pounds. Valve connections are provided so that in the event of an alarm of fire the pumps may be connected in series, maintaining the maximum volume capacity of one pump and doubling the pressure.

The layout of the plant is shown in Fig. 2, and it can be seen that provision has been made for doubling its capacity. At present there are two 150-horsepower Smith suction producers installed, using semi-anthracite pea coal costing $4.50 per ton. The coal is delivered from the railroad cars into a storage bin and brought by an underground screw conveyer to a bucket elevator which discharges into a hopper. From here the coal is spouted to the charging platform of the producers. Centrifugal scrubbers are used, belt-driven by an 8-horsepower induction motor. A 6-horsepower "Model" gasolene engine is installed to operate a blower for starting the fires and a small air compressor for use in starting the engine; it also serves

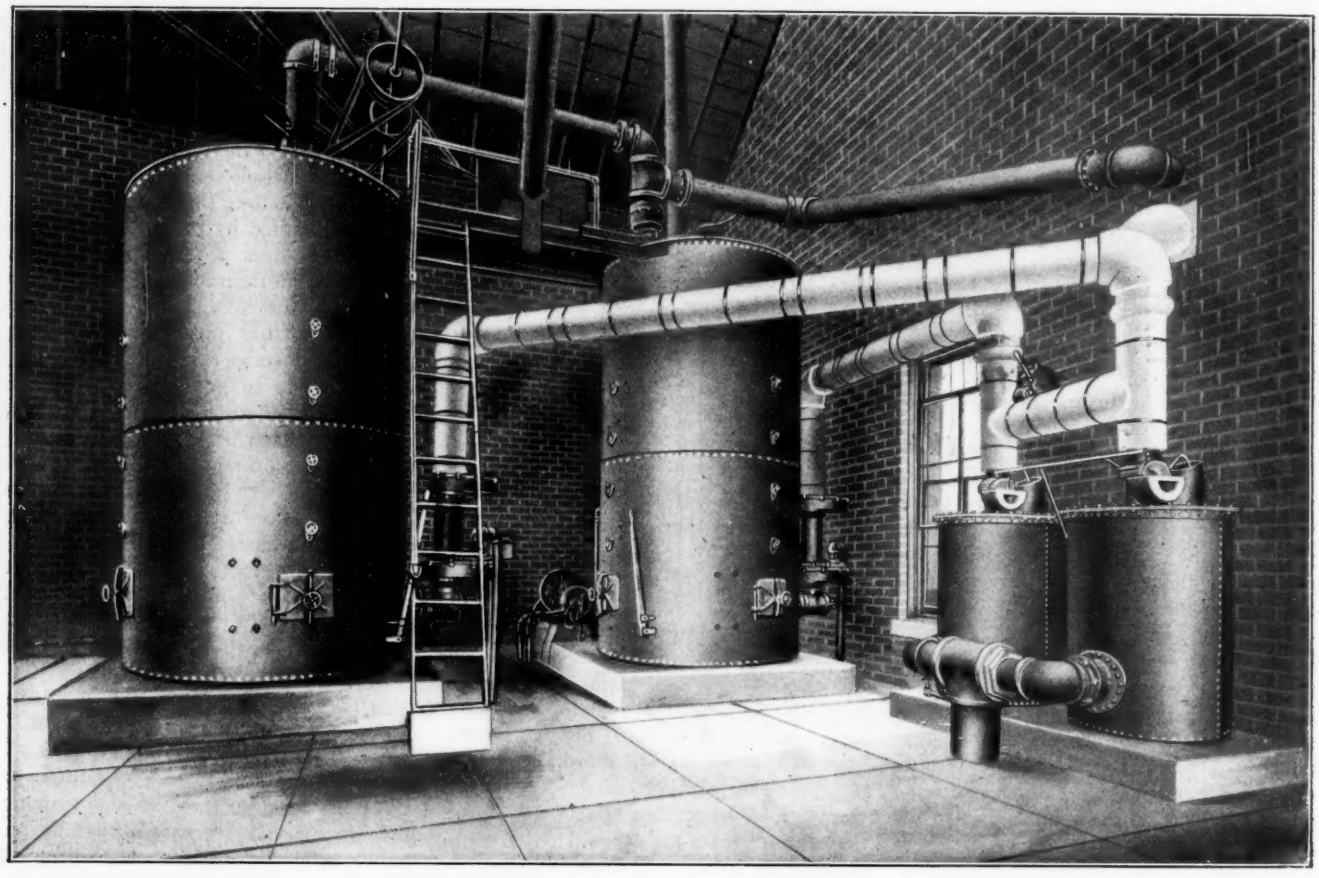


FIG. I. PRODUCERS IN MUNICIPAL GAS-POWER PLANT AT PERU, IND.

to furnish power for the centrifugal scrubbers before current is available for the motor.

The heat of the exhaust is utilized to generate the steam necessary for the producer generator and also to preheat the air used. In Fig. 1, at the right, can be seen the economizers in which this exchange of heat takes place; the exhaust gases from the engine pass in at the side and out at the bottom. The economizers also muffle the exhaust effectively, so that no other arrangement is necessary for this purpose, the exhaust pipe merely passing under the floor to a trench outside of the producer house.

Main Generating Unit

The main generating unit consists of a 300-horsepower vertical four-cylinder "Model" gas engine, direct-connected to a 200-kilowatt Western Electric revolving-field three-phase 60-cycle generator, with exciter belted from the main shaft. The engine, which was built by the Model Gas Engine Works, Peru, Ind., operates on the four-stroke cycle, with power strokes in the cylinders in the order of 1-3-4-2. An unusual feature is the construction of the cylinders, which are cast integral with the cylinder heads. This is well shown in Fig. 3, where the cylinder is seen to consist of one unbroken casting from the crank case up to the top of the head. This construction has been followed with satisfaction for years in all the smaller engines built by the company and is therefore continued in the larger sizes. It eliminates the gas joint and the water joint, and correspondingly reduces the liability to trouble. A partly sectional view of the cylinder is shown in Fig. 4. One important advantage of this construction is that by the elimination of the cylinder-head studs, an exceptionally large space is obtained for cooling water around the exhaust-valve cage, which is obviously advantageous in cooling this important member. The cage and valve complete may be easily removed from the cylinder for inspection and repairs. On the valve stem is located a dashpot to cushion the valve when closing; this is shown in Fig. 5, which illustrates the valve and cage complete with the rocker arm, spring and dashpot. From Fig. 6 the method of cooling the valve itself will be apparent. The stem is hollow and the incoming water passes through an inner tube down to the valve head and up through the annular channel between the wall of the valve stem and the outside of the tube, passing out through a hose connection.

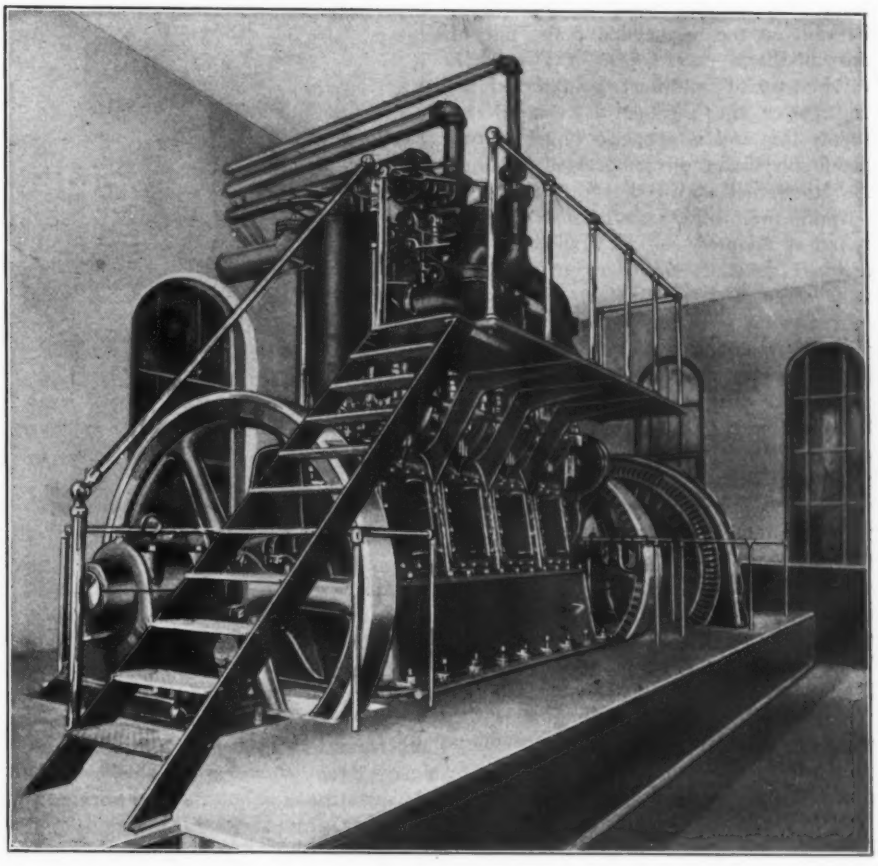


FIG. 3. ENGINE ROOM OF MUNICIPAL PRODUCER GAS-POWER PLANT AT PERU, IND.

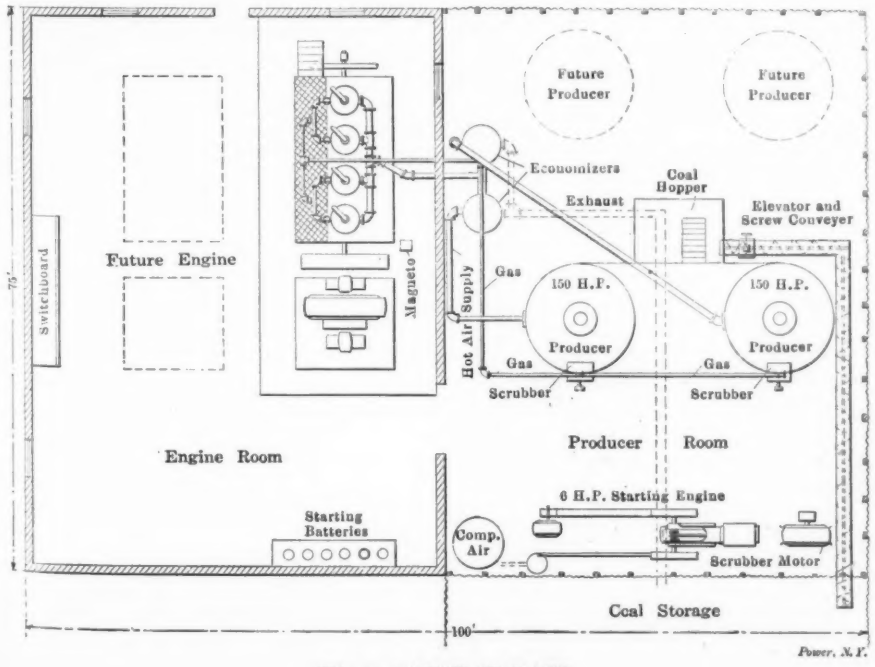


FIG. 2. LAYOUT OF PLANT

At the side of the cylinder is the inlet-valve chamber, over which a removable cover is bolted, making it easy to remove the valve for regrinding and repairs. Both valves receive their motion from cams on a shaft located outside of the crank case, the movement being transmitted through rollers to the push rods.

On the push rod leading to each exhaust is a small hand lever which when turned has the effect of lengthening the rod and causing the exhaust valve to remain open throughout all strokes. This isolates the cylinder so that examination can be made and minor troubles corrected without shutting down the engine.

Ignition and Starting

Ignition is effected by a make-and-break system. The igniter shaft lies along the tops of the cylinders, driven by bevel gears from the cam shaft. A belt-driven magneto is provided for regular operation and a battery is held in reserve.

For starting there is a sleeve carrying two auxiliary cams on the end of the cam shaft. When this is shifted over by a

lever it throws out of commission the inlet cam on the first cylinder and one of the auxiliary cams opens the exhaust valve at each revolution; the other auxiliary cam engages a poppet valve in an air-supply line and is properly timed to run the first cylinder on compressed air until the others pick up the charges of mixture.

With the solid construction of the cylinders adopted on this engine, one of the first questions occurring to an operating engineer would be as to the method of removing a piston. This is accomplished by taking out the exhaust-valve cage, screwing an eye-bolt into the piston and, after disconnecting the crank-pin brasses, lowering the piston and connecting rod down into the crank case; they are then taken out through the crank-case doors. The piston, as shown in Fig. 7, has three packing rings above the wrist-pin and one below; it is also provided with three oil rings.

The lower end of the connecting rod is of the marine type and a plain cast-steel box, working on a wristpin sleeved with bronze is used at the upper end. One of the special features of the engine is the provision for varying the compression pressure by shortening or lengthening the connecting rods. The rods are hammered-steel forgings, finished all over, and screw into the top casting where they are locked in position with 7/8-inch studs and nuts, as indicated in Fig. 7. With this arrangement the compression can easily be changed to suit any kind of fuel or any altitude. Fig. 8 shows the complete details of construction.

The Main Bearings

Five main bearings are provided, with an outboard bearing outside of each flywheel. The bearings are set solidly into the frame, each one being braced with a heavy reinforcing rib which extends downward to the bottom of the frame and is firmly grouted to the foundation. As the thrust on the bearings is all downward, no adjustment is provided other than that necessary to follow up on the bearing caps. In order to prevent unequal wear of the bearings by reason of differences in lubrication, splash lubrication is not relied upon entirely; oil is forced to each bearing by a pump driven from the cam shaft. Oil from this pump is also forced to each piston in two places,

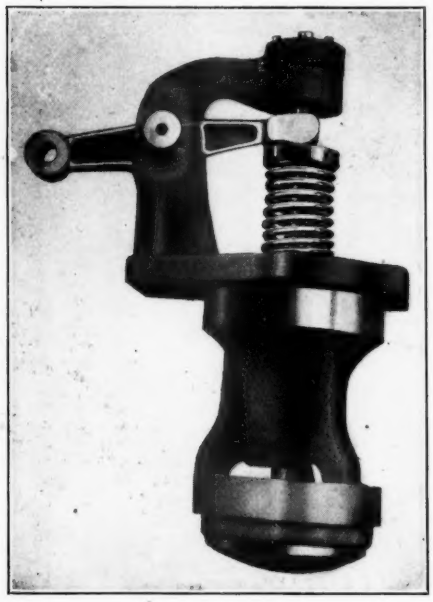


FIG. 5. EXHAUST VALVE AND CAGE

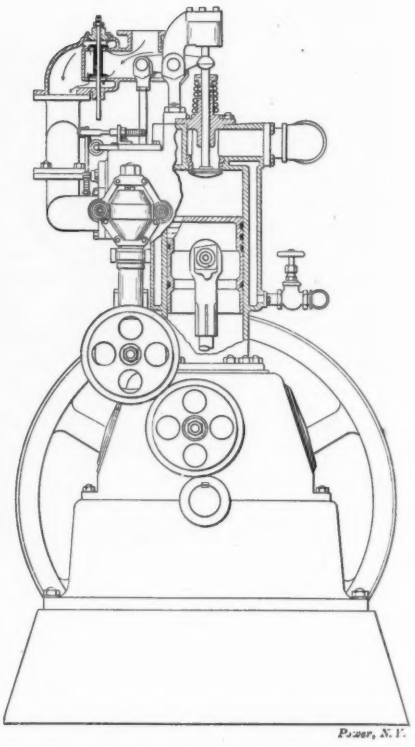


FIG. 4. PART SECTIONAL ELEVATION OF ENGINE

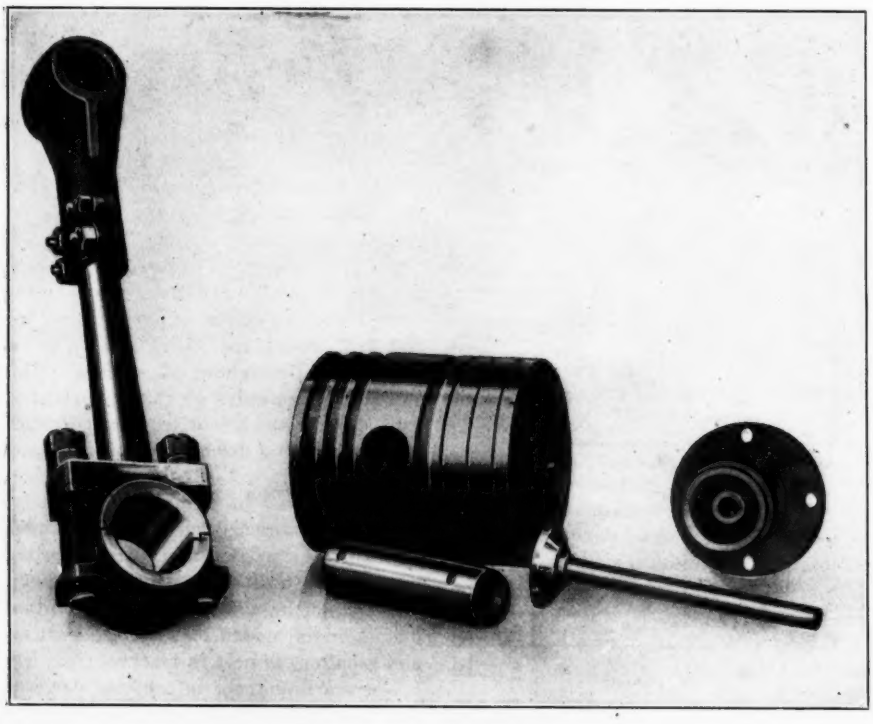


FIG. 7. PISTON AND CONNECTING ROD

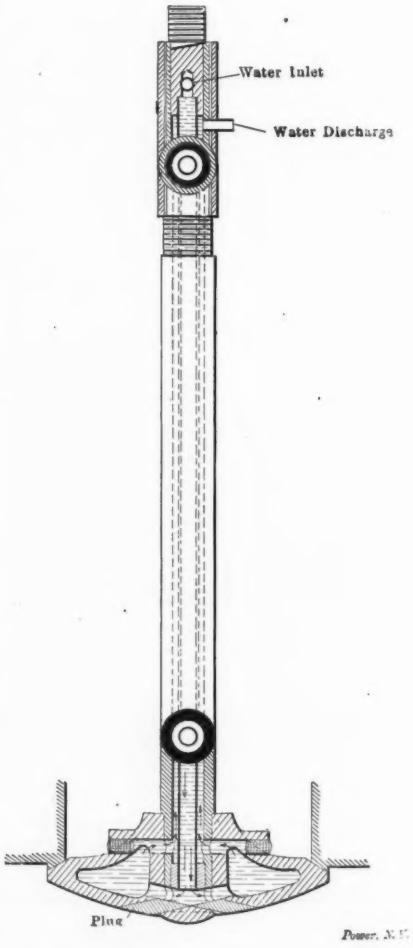


FIG. 6. SECTION OF WATER-COOLED EXHAUST VALVE

one on the thrust side and one on the opsite side.

Gas and air come to the engine through 5-inch supply pipes, each of which is provided with a lever-actuated gate valve by the manipulation of which the proper mixture may be obtained. The mixture then passes through a balanced throttling valve, shown in section in Fig. 4, which is controlled by the governor. The cylinders are connected in pairs by two inlet manifolds, and they are in turn united directly under the throttle valve.

The flyball governor is gear-driven and

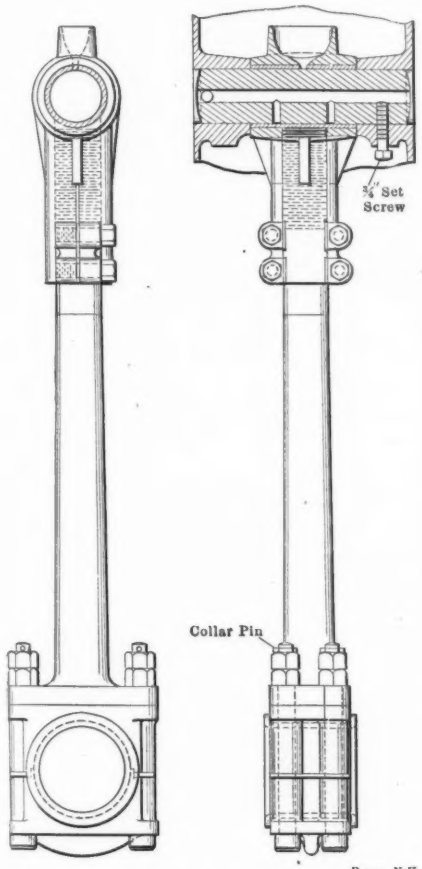


FIG. 8. DETAILS OF CONNECTING RODS

equipped with a dashpot to facilitate steadiness of operation. Ball-and-roller bearings are used in the governor mechanism and linkage.

According to a press despatch a company has been formed at Vineland, N. J., with a capital of $100,000, to develop the water power of the Maurice river. It will be known as the Maurice River Light, Heat and Power Company. A dam one-half mile long will be constructed, affording a head of 16 feet. Marcus Fry, of Vineland, is secretary.

The Combined Associations of Engineers of Brooklyn, N. Y., are up to the minute, especially in matters social, and they have already secured the date of July 18 at Bellwood park, N. J., for their annual outing.

Energy Charts for Steam

By R. M. Neilson

In steam-engine investigations involving the question of work obtainable from a given weight of steam, or the steam consumption to produce a given amount of work, it is, of course, necessary or desirable to know the maximum amount of energy obtainable from the steam. Mechanical-engineering pocket books and treatises on the steam engine commonly give tables of the properties of saturated steam, which include a column setting forth what is termed the *total heat* of steam. These "total-heat" values are often of great use; they represent the heat required to be put into 1 pound of water to raise it from 32 degrees Fahrenheit to the boiling point and convert it into steam at the boiling-point temperature. This temperature varies with the pressure, as is well known, and consequently the "total heat" depends on the pressure; at atmospheric pressure it is 1147 B.t.u.; at a pressure of, say, 200 above atmosphere, it is about 1200 B.t.u. A "total-heat" table is, as aforesaid, of much use. For example, with steam-generator problems it gives—after deducting the difference between the feed temperature and 32 degrees Fahrenheit—the heat required to be supplied to the water in the boiler per pound of feed.

These total-heat values do not, however, represent in any way the work which can be got out of the steam. If we are told that a steam engine consumes 12 pounds of steam per hour per indicated horsepower, with a steam pressure of 180 pounds and a vacuum of 26 inches (with the barometer at 30 inches), we may want to know what would be the steam consumption of an ideal engine working under the same conditions, or—what comes to the same thing—how many foot-pounds of work is obtainable from a pound of steam expanding from 200 pounds to a pressure of 4 inches of mercury. No tables, as far as the author is aware, have been published which give this information. The information can certainly be obtained with a little trouble from entropy-temperature or other heat-energy charts which are in fairly common use, but not, the writer considers, in a sufficiently convenient manner. The average engineer wants a direct reading.

The charts shown on the accompanying supplement were prepared by the writer to give this direct reading. It is unnecessary to say here how the charts were prepared,* but it is desirable to explain how they must be used and, to enable this to be done, it is necessary to say something about the conversion of the energy in steam into mechanical work.

Steam does mechanical work when it expands against a resistance. Such expansion may take place in a steam-engine cylinder, the resistance being the load on the piston, or it may take place in a nozzle—say of a turbine—the resistance being the weight of the steam, the velocity of which is increased. Work in the one case is done in moving the load on the piston and in the other case in giving kinetic energy to the steam.

The steam may receive heat during the expansion, as in the case of a steam-jacketed engine cylinder, or it may have heat abstracted from it (beyond that converted into work) and transferred as heat to other bodies, as in the case of an unjacketed steam-engine cylinder. When the steam neither receives nor loses heat, *as heat*, the expansion is commonly termed *adiabatic*; but, as there is some difference of opinion as to the meaning of this term,** the word *isentropic*, about which there is no difference of opinion, will be used. The word isentropic signifies that no heat is added to or withdrawn from the fluid during expansion and, therefore, from the law of the conservation of energy, it follows that if the expansion is isentropic the work done, whether in driving the piston or in giving kinetic energy to the steam, must be an exact equivalent of the heat energy given up by the steam. In the case of saturated steam, the heat energy given up corresponds to a definite drop in pressure, so that a fall from any pressure to any other pressure by isentropic expansion corresponds to the performance of a definite amount of mechanical work. This work, whether performed in moving a piston or otherwise, is expressed on the charts in foot-pounds per pound of steam; in the case of steam expanding in the nozzle of a steam turbine it represents the kinetic energy acquired by the steam.

The smaller chart gives the work of expansion from initial pressures of from 25 to 250 pounds to final pressures of from 15 to 200 pounds, the initial pressures being written over each curve, while the abscissas or horizontal distances represent the final pressures and the ordinates or vertical distances the mechanical work done.

The large chart is a continuation of the other and deals with final pressures below atmosphere, the scale for final pressures being made much greater (as is necessary) than in the other chart.

How to Use the Charts

As an example of the use of the charts, take the case of a noncondensing steam engine which consumes 24 pounds of steam per indicated horsepower per hour. The steam is supposed to be saturated but dry and at 155 pounds per square inch gage pressure—that is, about 170 pounds absolute. It is required to compare the

*This is explained in the author's book, "The Steam Turbine;" fourth edition, Longmans & Company."

**Those interested in this subject should see the discussion in *The Engineer*, London, December 15, 1908, *et seq.*

steam consumption of this engine with that of an ideal one; with an engine in which all the available energy in the steam would be shown on an indicator diagram.

Referring to the smaller chart, it will be seen that the energy obtainable from the expansion of 1 pound of steam from 170 pounds to 15 pounds (approximately atmospheric pressure) is 136,000 foot-pounds. Therefore to work at the rate of 1 horsepower for one hour, which means doing

$$60 \times 33{,}000 = 1{,}980{,}000$$

foot-pounds of work, would require

$$\frac{1{,}980{,}000}{136{,}000} = 14.6$$

pounds of steam, as against the 24 pounds actually used.

To show another and more important use of the charts, suppose that an exhaust steam turbine takes 33 pounds of steam per kilowatt-hour when the steam is supplied at atmospheric pressure (say 15 pounds per square inch absolute) and the vacuum is 27 inches, with the barometer at 30 inches (say 1½ pounds absolute pressure). It is required to find what less vacuum we can afford to have to obtain the same steam consumption, if we supply the steam to the turbine at 5 pounds above atmosphere, say at 20 pounds absolute. The kinetic energy obtained from 1 pound of steam expanding from 15 pounds absolute to 1½ pounds absolute is seen, on the large chart, to be 113,600 foot-pounds. Drawing a horizontal line through this point to cut the curve denoting 20 pounds absolute pressure, we find the final pressure to be about 2.1 pounds absolute; say 25.7 inches of vacuum with the barometer at 30 inches, the 5 pounds additional steam pressure therefore only allowing of a reduction of 1.3 inches of vacuum.

This assumes that the effective efficiency* of the turbine was equal in the two cases, which is generally approximately true under the conditions considered, but is not true with high steam pressures or very high vacua.

As a third example, suppose that it is desired to expand steam from, say, 200 pounds per square inch pressure, absolute, to 1 pound absolute, in four steps or stages so that the steam gives up the same amount of energy in each.

The energy obtainable from the complete expansion is, it will be seen from the large chart, 260,000 foot-pounds. Therefore, the total energy given up at the end of the first, second and third stages is 65,000 foot-pounds, 130,000 foot-pounds and 195,000 foot-pounds, respectively; and, by noting where the 200-pound curve cuts the horizontal lines representing these amounts of energy, we find the final pressure at each of these stages. These final pressures will be seen to be 70 pounds, 21 pounds and 5.05 pounds per square inch, respectively.

It may be well to point out that it must not be thought that there is an error because the chart gives the energy of 1 pound of steam in expanding from 70 pounds to 21 pounds, or from 21 pounds to 5.05 pounds, or from 5.05 pounds to 1 pound, as other than 65,000 foot-pounds. This is because, in the four-stage expansion considered, for every pound of steam at the start, we have not a pound of steam at the beginning of the second, third and fourth stages, but a pound of fluid which is partly steam and partly water, some of the steam condensing (according to well known laws) during the expansion.

Other uses of the charts will suggest themselves. In fact the writer has found that many problems that would have been ignored, or the results simply guessed, on account of the trouble of obtaining the available energy in the steam will, by the use of the charts, be scientifically solved.

*The effective efficiency is the ratio of brake work to available heat energy.

Value of High Pressure

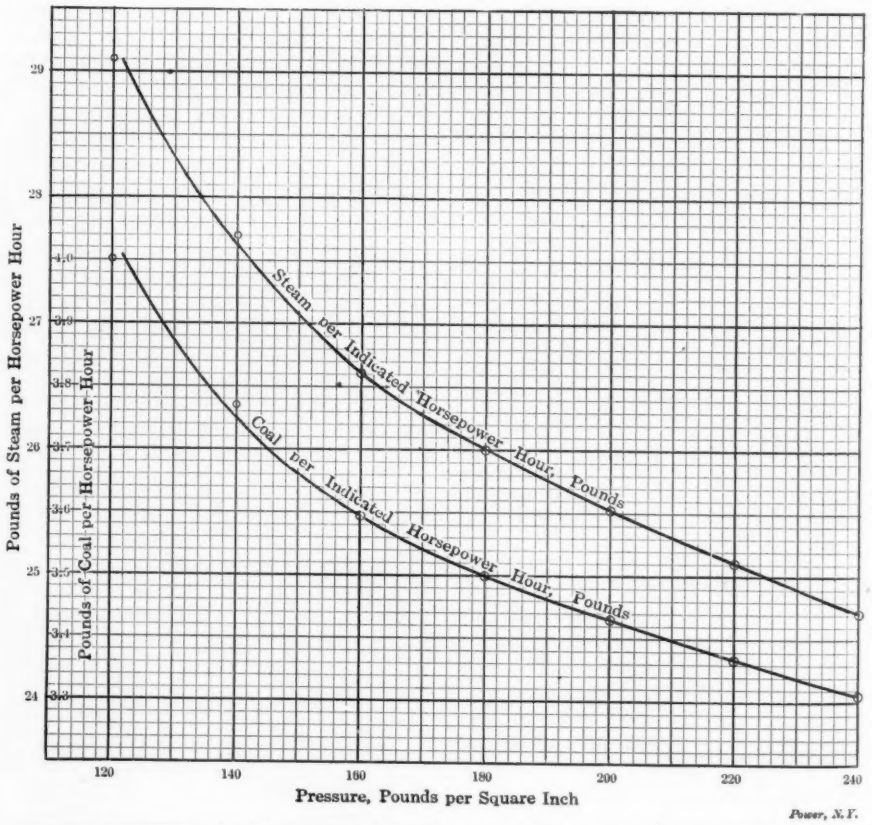
The advantages of high-pressure steam, even when used in the single-expansion cylinder of a locomotive, are brought out in the "Report on High-Pressure Steam in Locomotive Service," issued by the Carnegie Institution, of Washington, of which a resumé has been issued by the University of Illinois.

Tests were made under the direction of W. F. M. Goss, dean of the College of Engineering at Illinois, in the laboratory of Purdue University, while he was connected with that college, to determine the performance of a typical locomotive when operating under a variety of conditions with reference to speed, power and steam pressure. The results of one hundred such tests have been recorded and show that the steam and coal consumption vary with the pressure as follows:

Pressure Lb. Per Sq.In.	Steam Per Ind. H.P.-H., Lb.	Coal PerI.H.P.-H., Lb.
120	29.1	4.00
140	27.7	3.77
160	26.6	3.59
180	26.0	3.50
200	25.5	3.43
220	25.1	3.37
240	24.7	3.31

The same results are shown graphically on the accompanying diagram. They show that the higher the pressure the smaller the possible gain resulting from a given increment of pressure. An increase of pressure from 160 to 200 pounds results in a saving of 1.1 pounds of steam per horsepower-hour, while a similar change from 200 to 240 pounds improves the performance only to the extent of 0.8 of a pound per horsepower-hour.

An increase of pressure from 160 to 200 pounds results in a saving of 0.16 of a pound of coal per horsepower-hour, while a similar change from 200 to 240 pounds results in a saving of but 0.12 of a pound.



CURVES SHOWING RESULTS OF TESTS TO DETERMINE TYPICAL LOCOMOTIVE PERFORMANCE

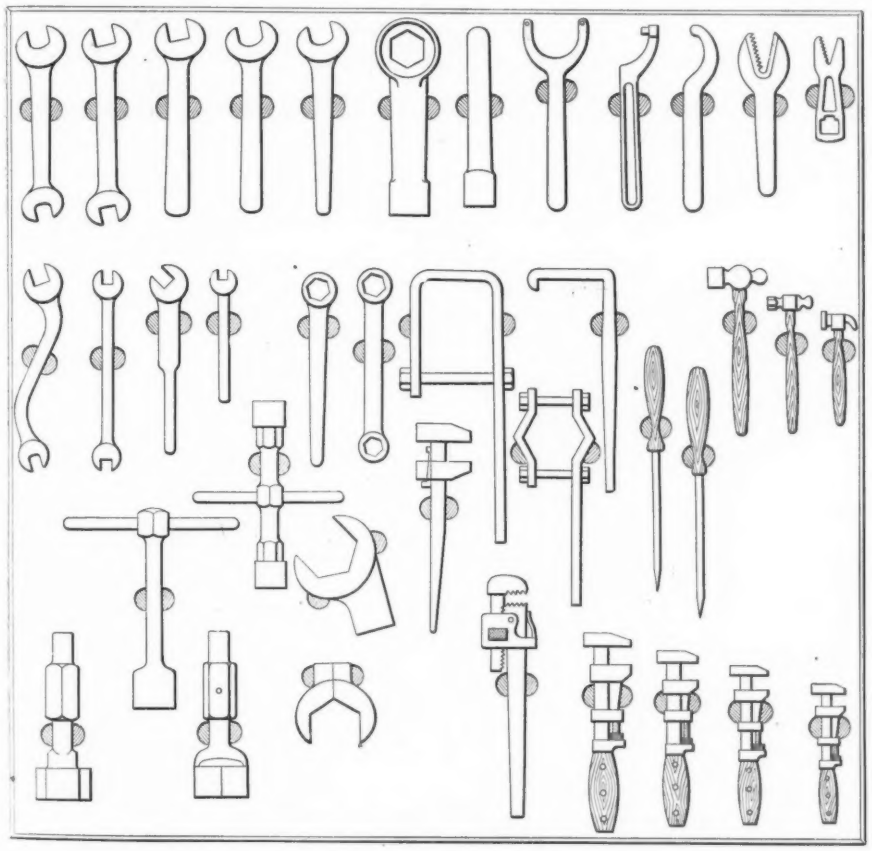
Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

How to Make a Tool Board

In order to make a tool board large enough to hold all the wrenches, hammers, screwdrivers, etc., one may have use for, and wishes to keep in a handy place, first gather all the tools together and arrange them on a table in the position desired, so as to take up the least space and yet not be crowded when placing the heavy part of all tools upward. Then by measuring the length and width the amount of lumber required is determined. Note the thickness of the thickest tool and make that the thickness of the boards.



A HOMEMADE TOOL BOARD

Call it, for example, 2 inches. Then get enough clear pine stock 1 inch thick, and the same amount of second quality, also 1 inch thick, to make the size of board desired. Butt-joint the best lumber and glue the joint, and clamp well. When dry, place all the tools on this board, arranged as when on the table, and make an outline drawing around each with a pencil. Then nail on the second quality of 1-inch stock to the back, with the strips running at right angles. Then bore and jigsaw through both boards spaces to conform to the shapes and sizes of the tools, making the fit snug. Mark each piece, 1, 2, 3, etc., as you saw them out; also number the places from which they were taken.

Next find the center of gravity of each tool by placing each across a knife edge, until it just balances, mark the spot on the tool with chalk and place the tool back in the sawed-out space. Then, in order to allow a good grip to be taken in each tool, gouge out an opening on each side in proportion to the size and weight of the tool. Next nail any light ⅜- or ½-inch lumber on the back, and so cover up all the openings at the back, and saw, split, or plane those "cut-out pieces," 1, 2, 3, etc., so that any difference of thickness between the tools will thus be compensated for by placing this backing in the openings. Glue or nail them in, and when the tools are in place all will be flush with the outside of the board.

Next nail Ogee molding round the edges and finish with sandpaper. Paint, first with drop black, then a good coat of wood filler on front, back and side, then two coats of shellac and two of furniture varnish. Rub down with mineral wool before applying the last coat of varnish. Next paint the bottom only of each tool receptacle white. The board when finished will have an appearance something as shown in the illustration.

With this tool board all the tools are in sight, and if one is missing the white back will act as a telltale. They are so arranged that no amount of brushing past them will knock them out.

If the back and front of such a board be varnished alike it will prevent warping. In hanging such a board I would advise the placing of two or more screws at the back close to the bottom, allowing them to stick out ½ inch, so as to make the board stand slightly back in hanging and so obviate the possibility of any tool falling out by jar or vibration.

HENRY BARNES.

Wellsville, N. Y.

Sparkless Commutators

Here are a few hints which, if followed by Mr. Baker, will help him to run his dynamo or motor without sparking: Keep the machine clean and dry and the commutator smooth, true, and free from carbon dust and flat places. Do not allow the copper coating of the brushes to come into contact with the commutator, but scrape it off about 1/16 inch above the contact point, and file or sandpaper the heel and toe of the brushes round, after sandpapering each to a fit with 00 sandpaper. Do not use lubricants of any kind on the commutator; by keeping the brushes clean there will be no need of it. Set the brushes at diametrically opposite points when making contact on the commutator at an angle of about 60 per cent., so as to insure light and sure contact, and be sure the backs of the brush and holder make good contact. When the load is light move the brushes back and forth by the rocker arm until the proper lead is found and then fasten at that point.

If Mr. Baker follows these simple rules and still has sparks at the brushes he had better send for the troubleman.

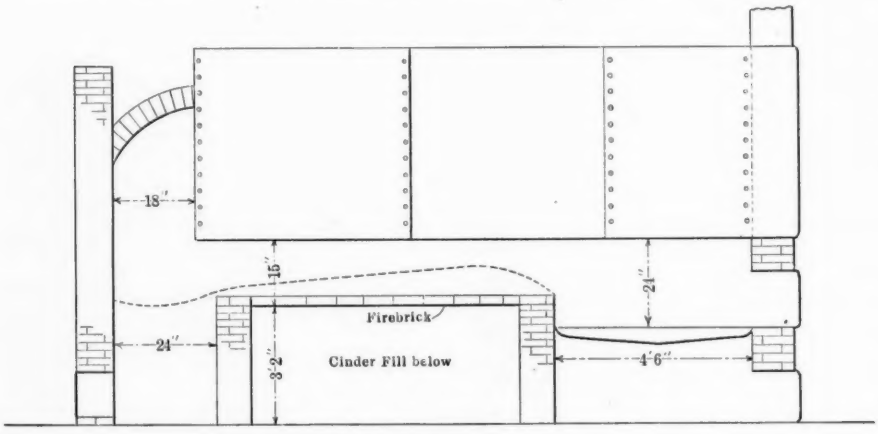
FRANK FERGUSON.

Adams, Mass.

Burns Too Much Coal

In our electric-light plant we have two 66-inch by 16-foot return-tubular boilers, set as shown in the accompanying sketch. We burn slack soft coal and occasionally run-of-mine, our regular working steam pressure being 100 pounds.

One boiler only is operated at a time, and usually at a comparatively light load, our runs being from sunset to midnight, with a short morning run during the winter. Our peak load amounts to about 75 horsepower for two hours, gradually running down to about 15 horsepower at midnight.



ONE OF THE BOILERS IN MR. SPRAGUE'S PLANT

I have never operated a boiler set in this manner for burning the fuel we do. I refer more especially to the combustion chamber, its construction making a contracted passage for the gases. The dotted line shows how I found the combustion-chamber ashes heaped up on my first cleanout, the rear end being entirely full. I have formerly been accustomed to combustion chambers that were much larger, either being entirely open behind the bridgewall, or sloped off to the rear from the top.

Our furnace is 6 feet wide by 4½ feet long. I am of the opinion that we would have better results from our fuel if the grates were set farther from the boiler shell, and in view of the light load it may be advisable to brick off part of the grate bars in the rear. The boilers have flush fronts and the lower part is separate, which would facilitate the construction of a dutch oven, should such construction seem advisable. The stacks are 32 inches in diameter and 60 feet high, and we have an excellent draft, but no damper regulator.

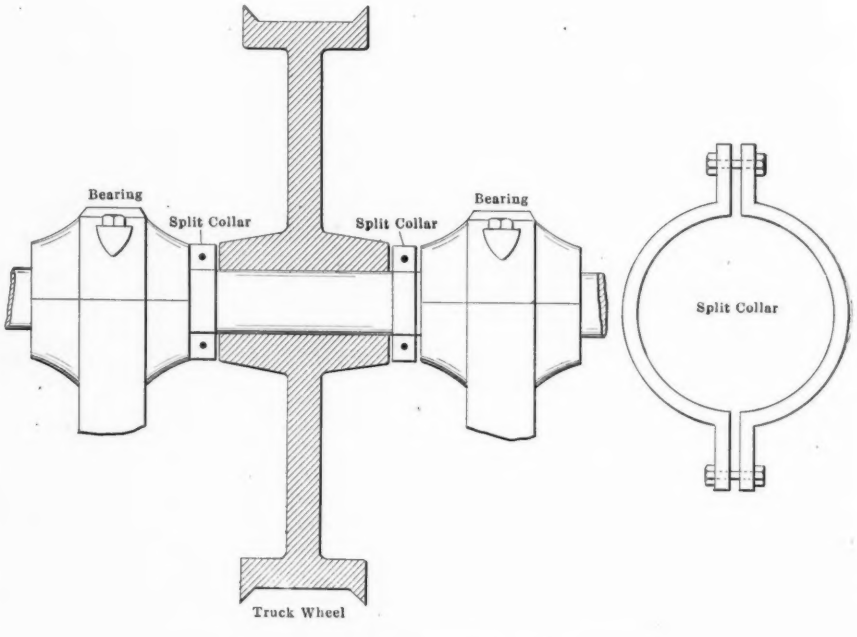
In checking over our output I find we are using about 18 pounds of coal per kilowatt, which I consider nearly double the amount we should require. Our engines are all in good condition and first-class adjustment. We run noncondensing.

G. S. SPRAGUE.

Geneva, Neb.

Remedying a Traveling Crane Trouble

A traveling crane was driven by a double vertical steam engine and boiler located on the crane. The engine and boiler were replaced by a motor last summer, and after a few days it was noticed that the trucks on each end of the crane were not running in line.



HOW A TRAVELING-CRANE TROUBLE WAS REMEDIED

Upon examining the wheels on both trucks I found considerable play between the two bearings and the hub of the wheels, as shown in the illustration.

I filled this space with split collars, but in order to give the wheels a little play, a ¼-inch space was left between the hub and the two bearings. After the collars were put in place and the crane started, no further trouble developed.

H. JAHNKE.

Milwaukee, Wis.

A Lighting Problem

In reply to Mr. Rolph's letter, as the transformer voltages or the lamp voltage were not given, I assume that the voltages are 110 volts between the middle lead and the outside ones and 220 volts between the outside leads of the transformer, and that the lamps are for 110 volts. If the lamps are of the assumed voltage, then series connections would not do; but if the lamps he has in mind are designed for series grouping, and if desired to run that way, it would be advisable to have a choke coil across the lamp terminals, so that in case the lamp failed, the coil would take its place and keep the remaining lamps burning.

As the town is small, it would be better to run the lamps in multiple and use 110-volt lamps. This would only require another length of wire in addition to that required on the series circuit, and the extra insulators and pins. This would do away with the necessity of the choke coil, and each lamp would be independent.

To balance the transformer it would require seven of the lamps per circuit, one circuit taking the middle and outside lead and feeding in one direction and the other circuit taking the middle and opposite outside lead and feeding in the other direction.

Another scheme would be to feed the circuits with 220 volts and connect the lamps in multiple series. This can be best determined by local conditions. The arc circuits are connected all right, but it is best to run the three wires both ways from the transformer for the commercial

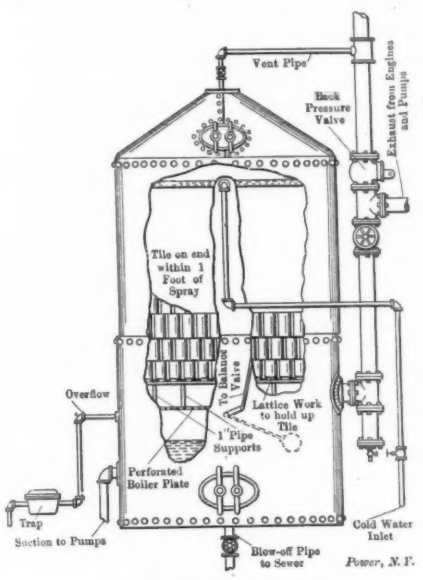
circuits, and care should be taken to keep the load evenly divided between them.

JAMES E. KILROY.

Lincoln Place, Penn.

A Homemade Heater

The accompanying sketch is of a homemade heater made out of an old tank. It is 6 feet in diameter and 10 feet high, and takes care of 1000 horsepower of



A HOMEMADE HEATER

boilers. The draintile must be renewed about once a year, according to the condition of the feed water. It has been in use about one and one-half years and at the present time there is no sign of any oil in the boilers.

JOHN S. JUNG.

Milwaukee, Wis.

Difficulty in Starting a Motor

One of our customers using a 5-horsepower 220-volt two-phase motor experienced considerable difficulty in starting, due to the belt slipping off. The motor was not furnished with a starting compensator and the owner did not care to go to the expense of procuring one, so we rigged up a four-pole double-throw switch, as shown by dotted lines in Fig. 1, and at the same time connected the neutrals of the two-pole transformers together.

The switch was thrown to the right, the motor starting off without a jerk, and when up to speed the switch was thrown to the left. On starting the situation was as shown in Fig. 2, the motor leads *2* and *3* being connected to line *2*, motor lead *4* to line *3*, and motor lead *1* to line *1*, making one-half of each phase acting together on a full coil of the motor; this gave 155 volts instead of 220, as the voltages of the two phases are 90 degrees apart in

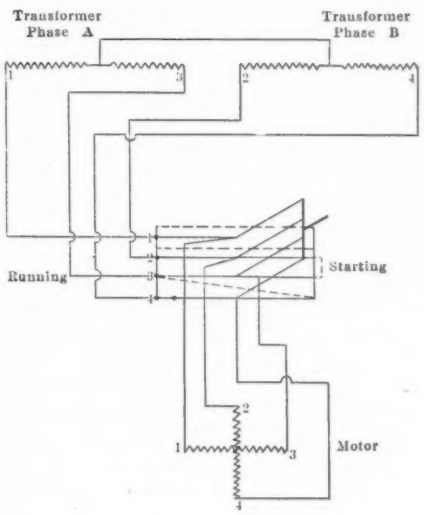


FIG. 1

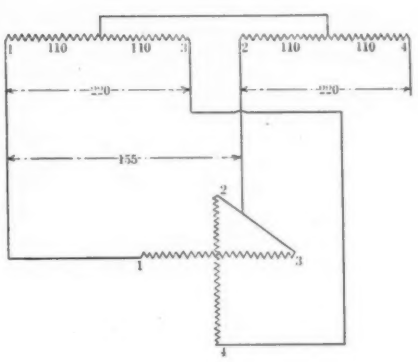


FIG. 2

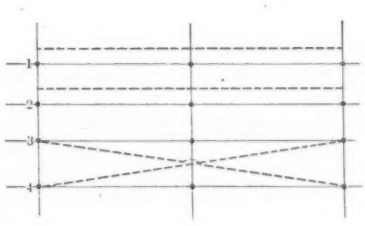


FIG. 3

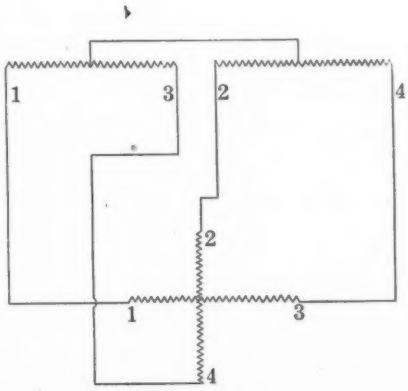


FIG. 4

phase and the resultant voltage is the square root of the sum of the squares, or

$$\sqrt{110^2 + 110^2} = 155.$$

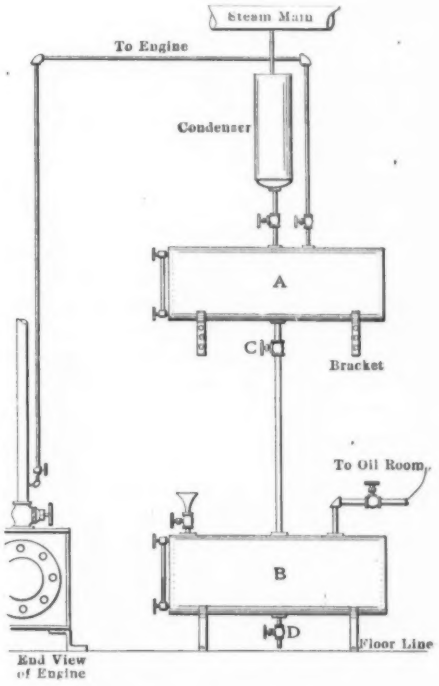
The same effect would be obtained by connecting the switch as shown in Fig. 3, giving result as shown in Fig. 4, and would give the same current in all coils of the transformers, but the starting current is on for such a short time that this is not necessary.

JOSEPH B. CRANE.

Broadalbin, N. Y.

Cylinder Oil Distributor

The oiling system herewith described is in operation in a large steel mill. In the engine room are twelve engines in a row, all the same size and speed. There is not a lubricator in the plant. The cylinder-oil tank, which is located in a convenient place, has one pipe connection to the steam main and another to the sight-feed glasses. The supply for each engine is regulated by a feed valve at the bottom of the glass. The line from the steam main to the supply tank is provided with a condenser.



CYLINDER-OIL DISTRIBUTOR

The novelty of this system is the double-tank arrangement. The regular tank *A* (see sketch) is placed on the wall and supported by brackets. Tank *B* is placed on the floor and is connected with tank *A*, which is provided with a gage glass. When tank *A* is nearly empty, *B* is shut off from it by closing the valve *C*, and it is drained from the bottom drain pipe. The valve *D* is then closed and the tank filled with oil. Upon opening the valve *C* the oil makes its way to the upper tank.

The advantage of this arrangement is that there is no need for an expensive outlay for lubricators and the oil supply is not cut off from any engine or pump while filling.

EDWARD T. BINNS.

Philadelphia, Penn.

The Actual Cost of Power

In one of the recent issues, in the editorial on "The Actual Cost of Power," I read the following statement: "It is important for the engineer to be able to figure power cost, including the fixed charges, however, when occasion arises, and to appreciate the influence of the annual interest, depreciation, insurance and taxes on the unit cost of power produced." True, this is important, but to what end? To find out if the production is economical, or if the plant is efficient?

The most accurate computation of the cost of power can only show that its unit cost has increased or decreased; and in the editorial mentioned we find the statement that the unit cost decreases when the output increases, and *vice versa.* Therefore, it follows that by knowing his actual cost of power the engineer will only learn that the good or poor work of the sales department has made him produce cheaper or more expensive power. What will he gain through such knowledge?

He will have sufficient data to "kick" against the management of the concern; he will learn—perhaps—what the profits of his employers are; he will learn how difficult it is to do another man's work, and he will be kept in training in the high art of arithmetic. All this is a considerable gain to him personally, but is it all so very useful and necessary?

He will not have learned what his task really is. All these computations will not show him what his part is in the process of decreasing the cost of production; they will not teach him how to increase the immediate efficiency of his power plant. He will have to ask his employers to engage standard-practice specialists, who will determine standard-unit costs and work out a system of record keeping which will enable the engineer to find out at each given moment what the total efficiency of power generation is, where the leaks in the numerous steps of the transformation of energy, from the coal pile to the switchboard are located, how large the losses are in each step of this process, and which of these losses depend upon inefficient operation and which upon outside causes.

By the actual unit cost of power generated it is impossible to know whether the plant is doing well and the engineer is up to his task. The data of previous months are of little use, as it is valueless to compare casual and inaccurate figures with others which are also indefinite. That would only be an attempt to bluff oneself and others by irrelevant and absolutely misleading data. To make any comparisons one must have scientifically determined standards, just as one must have a zero point and a boiling point on a thermometer scale.

It often happens that with a high actual unit cost the efficiency is much higher than with a lower one, and then the activity of the engineer must be in quite another direction than the one which might be prompted by the casual figures of actual cost. The type of calculations recommended in the article quoted will be also useless for a comparison with unit costs of neighboring power plants. These plants have other prices and specifications of fuel, other fixed charges, etc., and, therefore, there is very little sense in trying to compare unit costs before they can be measured by a common scale and from a common zero point; in other words, before the plants are standardized and before special efficient engineers have given into the hands of the permanent staff the scientific methods of determining the plant's efficiency.

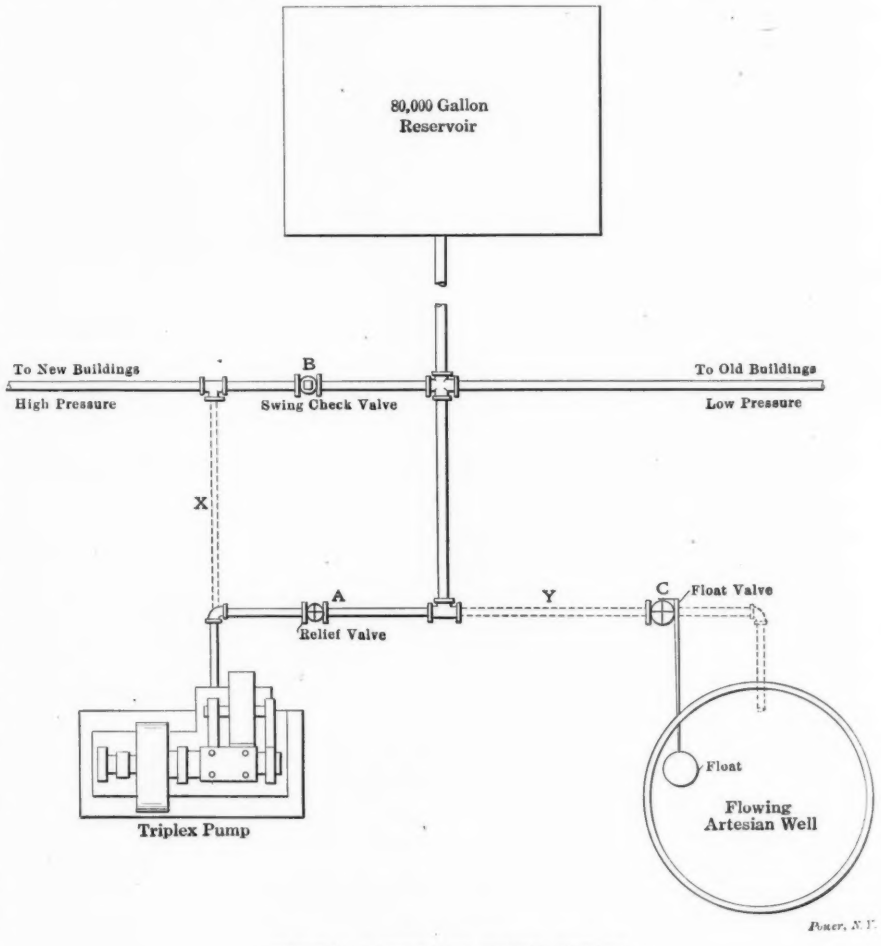
W. N. POLAKOV.

New York City.

Increasing Water Pressure

Several years ago about half of a large factory was rebuilt, the old buildings being replaced by new and modern structures two stories higher. Difficulty was at once experienced in getting water to the top floors of the new buildings.

A water pressure of 27 pounds was maintained by an 80,000-gallon reservoir and a triplex power pump. The new buildings required between 35 and 40 pounds pressure, so it was necessary to raise this pressure about 13 pounds, while keeping the pressure on the rest of the system at its normal value.



GENERAL LAYOUT OF WATER SYSTEM

The sketch shows the general layout of the system. The full lines, with the exception of the valves, indicate the system as it was before alteration. The dotted lines and valves show the additions that were made.

On the top of a hill, half a mile away, is the 80,000-gallon reservoir. At the factory is a flowing artesian well. The reservoir is connected through the pump to the cistern of the well, and the factory mains are tapped from a point between the pump and reservoir, so that the factory may draw its water from either source. The reservoir is kept full by the extra water pumped when the pump is running.

The required extra pressure was ob-

tained by putting a relief valve set at 35 pounds between the pump and the reservoir at *A*, a swing check valve on the high-pressure supply pipe at *B*, and connecting the high-pressure main beyond the check valve to the pump through the pipe *X*. This arrangement permitted the pump to feed the new buildings at 35 pounds pressure, or more, while the old buildings remained on the lower-pressure system. In case the pump was shut down, the reservoir would supply both old and new buildings, the former as formerly, and the latter through the swing check valve, but at a low pressure.

During certain seasons of the year the flow of the well declines and becomes insufficient to supply all the water needed. In order to keep enough water in the well cistern to supply the pump for the higher buildings, at such times, a supply pipe *Y* was tapped from the main to the cistern through the float valve *C*, which was set so as to keep the water at the required level.

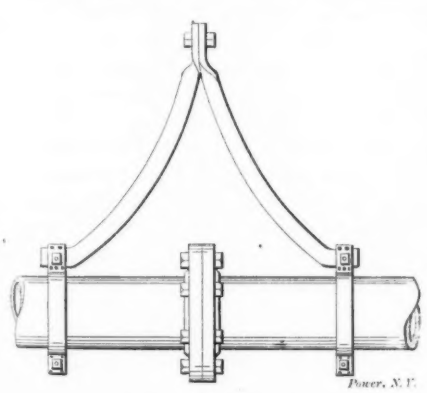
The desired results were thus accomplished at the expense of three valves, about 10 feet of piping at *Y*, and some 3 feet of piping at *X*. The plan has proved entirely satisfactory, and has been working for several years.

W. W. PARKER.

Chicago, Ill.

Support for Flanged Piping

In putting up large steam pipes I have noticed that some steamfitters and engineers allow long spans in the steam lines,



FLANGED-PIPE SUPPORT

and although hangers are used, a great strain still remains on the flanges.

The way I have done is to use two clamps on steam pipes, one on each side of the flange, and bolted tight to the pipe (see illustration). I then take two pieces of iron and make a V-shaped piece to act as a keystone and prevent the pipe from sagging, thus removing the strain from the flanges.

E. H. MARZOLF.

Wheeling, W. Va.

The Centrifugal Pump

The discussion on centrifugal pumps has been very interesting to me and I think some good practical points have been brought out. George H. Gibson very clearly explains his idea of the action of the water in his article in the January 12 issue, page 122, but I think his argument applies more to pumps with the circular casing than those of the volute form, and as it was a common volute pump that started the discussion, I confined myself, in a previous letter, to this type of pump, so I was not as surprised as Mr. Gibson imagined when I heard of "other types." I will give my reason for wishing to know if the statements relative to closing the discharge valves of centrifugal pumps while running at full speed applied with equal accuracy to the common low-lift volute pump.

Some time ago I was visiting a large manufacturing establishment and the engineer was showing me a centrifugal pump they used for filling a large reservoir, when all at once the pump started to run hard, the belt slipped and snapped and finally came off the pulley. The engineer excused himself with the remark that some fool had shut down the discharge valve by mistake and that he was going to have a lock put on it. With that he left me and I went over the rest of the plant and eventually went home without seeing the engineer again.

This pump was a common volute pump and I should guess that the discharge pipe was about 10 inches in diameter. I never thought any more about it until I saw the statement about the decrease in power needed when the discharge was closed, and as this was so directly contrary to this incident I naturally was doubtful if this applied to this type of pump, and so asked for more data. I note that G. H. Escher, in his article on page 247, states that in his experience with about 25 centrifugal pumps he found that the power required to work against a column of water without discharge is about equal to the power needed when discharging fully under seven-eighths of the head. I mention this in comparison with Mr. Gibson's article merely to show that different results appear to be obtained under various conditions. I also note that Mr. Escher's experience is that centrifugal pumps when operating with discharge closed require less power, but I am of the opinion that his pumps were not of the common volute type, as he speaks of an 85-foot lift.

I am sorry I cannot make any definite statement myself, but I have never tested one of these pumps to see what effect closing the discharge valve has, and I do not know positively that the pump I saw that day threw off the belt because the discharge valve was closed, but the engineer certainly seemed to know what the trouble was and from the way he spoke it seemed as though this had happened before.

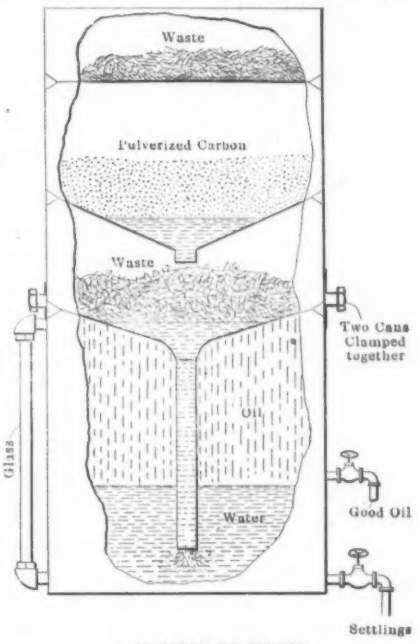
Has anyone had a similar experience with a common low-lift volute form of centrifugal pump?

GEORGE P. PEARCE.

Exeter, N. H.

A Homemade Filter

The sketch shows a filter I have just completed. It is made out of two 10-



A HOMEMADE FILTER

gallon cans. I cut the top out of one can and the bottom out of the other and used them for the strainers in the top can. It is painted so I have no occasion to feel ashamed of it.

Although it works well, I had much rather have a proper filter made by any good firm.

E. A. YOUNG.

Isabella, Tenn.

How to Take Indicator Diagrams

Recently, J. B. Latour showed some indicator diagrams of an interesting nature, and desired someone to explain what caused them. I have taken diagrams showing the same trouble, and have come to the conclusion that it is caused by the manipulation of the indicator. In taking cards, if I start when the pencil of the indicator is down to its lowest range, or where it makes the atmospheric line, the instrument nearly always makes two lines, as Mr. Latour's did. But when I start taking a card with the pencil at its highest range or when full pressure is on the piston of the indicator, my indicator makes a nice clear-cut diagram.

G. W. HARDING.

Lexington, Neb.

Scaled Boiler Surfaces

Referring to the discussion of Hilton Williams' article by H. E. Gansworth in the January 5 number, and by Eriths' Engineering Company, Ltd., in the February 9 issue, the tests quoted by Mr. Gansworth included an item of considerable interest, but not mentioned in his quotation. Two boiler tests were made on a locomotive-type boiler working at a high rate of evaporation. One test was with the tubes and fire sheets covered with an average of ⅛ inch of carbonate scale. The other test was made under exactly similar conditions, but after the boiler had been cleaned of all scale. The result was an average of 10.5 per cent. loss due to this thickness of carbonate scale.

At another time, performance sheets expressed in terms of power generated, all under similar conditions, were kept for three months previous to and for three months after scale removal. The scale was mainly carbonate, and the result at the coal pile was 10 per cent. in favor of clean surfaces. On the other hand, many tests which are on record, and whose reliability is beyond dispute, tend to indicate that the effect of scale is much less than as herewith indicated, and others show that it is higher. I believe that these disagreements may sometimes, though not always, be reconciled when the real governing conditions are taken into account.

Rankine, I think, found that the heat resistance of dry carbonate-of-lime scale is about seventeen times that of iron, and that of sulphate of lime forty-eight times. Carbonate scales are soft and porous and sulphates hard and dense. The carbonate coating may be considered as a pipe covering, only the particles are somewhat cemented together instead of being loose. No engineer would expect much of a pipe covering that was saturated with water. The heat resistance of a porous scale in a boiler should be looked at in the same light.

If the rate of evaporation is low, and especially if the scale in question is in a part of the boiler, or its auxiliaries, where the flue gases have lost some of their heat, and the feed water has not reached its maximum temperature, the scale will be damp to some extent. If, however, the rate of evaporation is high, the body of the scale will be dry, or contain nothing but highly superheated steam, and in this condition it approaches the condition of a dry pipe covering, and we have an excellent heat insulator which, considering its thickness, compares favorably with what we know of the value of magnesia pipe coverings in general. This may account for the fact that tests made at high rates of evaporation generally show decided loss on account of scale. In any case, especially at low rates of evaporation, the composition of the scale should be taken into account and this may account for the vastly different results that have been obtained.

Even if in some cases porous scale causes only slight loss at low rates of evaporation, the fact that at high rates the loss is great makes the subject of considerable importance in view of the results of certain tests at the St. Louis Exposition, and the resulting tendency greatly to increase the volume and, therefore, the velocity of gases passing over any given heating surface, all with a view to greatly increasing capacity at very slight cost in economy.

E. W. Fiske.

Urbana, Ill.

Repairing Commutators

In the plant where I am employed there are three 250-kilowatt 600-volt three-phase rotary converters, all of which are subject to flashing, one being extremely so. This trouble probably occurs more frequently in rotary converters than in direct-current generators, due to the "bucking" or flashing-over characteristic of some of these machines. If this burning occurs out on the brush-bearing portion, or outer end of the commutator, it is not so difficult to handle, but when it is on the inner end, where the armature leads connect to the commutator, it is much more serious, as it is hard to get at it.

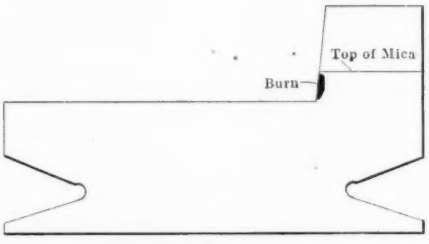


FIG. 1

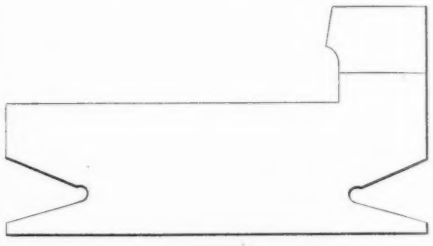


FIG. 2

In the three converters mentioned, burning at this point became so serious that it was necessary to cut off the copper with the lathe, increasing the length of the brush-bearing portion of the commutator until the tool went in behind the burned places, leaving the hard, firm mica between the bars. Figs. 1 and 2 will illustrate the idea, Fig. 1 showing the original shape of the commutator bar and Fig. 2 how it was cut away.

While the remedy suggested by Mr. Work, a solution of silicate soda and a filler, in the January 5 number, is probably the best we have, it is by no means a panacea. An experience extending over three years convinces me that one should not be too hasty in congratulating himself on the permanency of the repair, especially if the commutator is run where oil is likely to get on the surface, or if it is on a high-voltage machine. In some instances this filler seems to deteriorate under the action of oil.

As Mr. Work says, every particle of charred mica must be removed, and if the job is undertaken by anyone who does not fully realize the importance of having the cavity thoroughly cleaned, failure is most sure to result. The writer has used both powdered glass and plaster of paris as a filler for the silicate soda (water glass) solution, and prefers the former where any length of time may be had for the repair to dry before starting up the machine. With powdered glass, the mixture forms a doughy mass which is easy to handle and force into the cavity. If plaster of paris is used the mixture hardens almost before it can be applied, making it necessary to work very rapidly in applying, or else break it up again after it has set, which is bad practice.

With either filler, if the cavity is small, as between two commutator bars, the mixture will harden in a few minutes sufficiently to allow the machine to be started, but if the cavity is large some time will be required for it to dry, the longer the better. Where the mixture before drying forms a ground, the drying has been in some instances hastened by allowing a light current to flow through the filling to the ground, but care must be exercised that it does not become too warm.

One of the converters previously mentioned has been running for several months with a two- or three-ounce plug of the mixture (with plaster of paris as a filler) packed into a hole between the commutator bars and the clamping ring, the hole having been burned out from a ground against the clamping ring. In another is a plug of powdered glass as a filler between the bars of the commutator and the clamping ring of the thickness of the original insulation. When this repair was made the machine tested partially grounded, but the slight leak through the mixture soon dried it out until the machine tested clear. If a good fit can be secured it is probably better to use mica than the mixture spoken of, but the fit must be good or the trouble will surely appear again. If the trouble is on the outer corner of the commutator a crevice may be sawed out between the bars across the corner, care being taken to see that the bottom of the crevice is perfectly straight. A tight-fitting piece of mica with a perfectly straight edge should then be forced to the bottom of the crevice, after which the bars should be lightly calked on each side of the mica to hold

it in place. The mica can then be trimmed off and smoothed up to conform with the surface of the commutator.

In a job of this kind it is important that more than an approximate fit be obtained and the angle at the surface of the commutator formed by the new piece of mica should not be less than 45 degrees. If so, the point of the new piece at the surface of the commutator will be so thin it will not stay in place, furnishing an inviting place for a new beginning of the trouble. In one or two instances the writer has sawed out the mica across the end of the commutator down to the clamping ring, securing a square corner for the new piece at the surface.

Whether mica or the filling mixture is used the work must be most carefully done or permanency will be lacking, and even with the utmost care permanency will be in doubt.

Where circumstances justify, if the trouble has become very serious, it is probably better to strip off the clamping ring, loosen up the bars and put in new insulation and also commutator bars, if the old ones are badly damaged.

C. L. GREER.

Handley, Texas.

The Modern Surface Condenser

In Mr. Orrok's letter in the December 22, 1908, number, he says that where good surface efficiency is possible and there are no serious air leaks, the air pump of ordinary size is usually more than sufficient. This is a rather vague statement, and not at all on the scientific lines he is anxious to pursue. When are air leaks beginning to become serious, and what does he consider the ordinary size of an air pump?

Mr. Orrok will, I believe, have noticed the great difference in opinions, and in actually operating plants, as to the size of air pumps. If he invites five tenders for certain conditions he will find the air pumps varying in sizes by at least 100 per cent. What the capacity of the air pump means and how it affects the surface efficiency of a condenser I will show by an example.

We will assume a condenser of a certain cooling surface, condensing a certain weight of dry-saturated steam per hour, accompanied by a certain weight of air from leaks and other sources, the cooling water of a fixed quantity per hour entering at 25 and being discharged at 40 degrees Centigrade. We further assume that this condenser maintains an absolute pressure of 0.12 atmosphere, and consequently the steam temperature at the condenser inlet will be 50 degrees Centigrade. The condenser is further assumed to be built strictly on the countercurrent lines, so that the mixture of air and vapors removed by the air pump may have a temperature of 30 degrees Centigrade. The mean difference of temperatures between the steam and water spaces will then be

$$\frac{50-40}{2}+\frac{30-25}{2}=7\tfrac{1}{2}$$

degrees Centigrade. The tension of the vapors at the air-pump suction is then 0.04 atmosphere absolute, corresponding to the temperature of 30 degrees Centigrade, consequently, the tension of the air at the place of removal will be

$$0.12-0.04=0.08$$

atmosphere absolute (Dalton's law).

We now increase the effective displacement of the air pump by 100 per cent., but otherwise leave everything unchanged. The next consequence will be that the pressure of the air at the air-pump suction drops to one-half of the original pressure, or 0.04 atmosphere absolute. Some trial calculations will then show that in order to preserve the original mean difference of temperatures between the steam and water spaces, that is 7½ degrees Centigrade, which is necessary to keep the condenser doing its work, the initial temperature of the exhaust steam must drop to 45 degrees Centigrade, and the temperature of the mixture of air and vapors at the other end of the condenser must rise to 35 degrees Centigrade, when the total pressure will be 0.095 atmosphere absolute, leaving 0.055 atmosphere absolute for the vapors withdrawn with the air, this corresponding to 35 degrees Centigrade, and the total pressure to 45 degrees Centigrade. By doubling the air-pump capacity we have thus improved the vacuum by 0.025 atmosphere, or nearly ⅜ inch. But the velocity of the exhaust steam at the inlet end of the condenser will now be 31 per cent. higher, and that of the air and vapors leaving 100 per cent. higher, and besides the percentage of steam in the mixture will be higher, and this is where the surface efficiency comes in, which will be increased, resulting in a still better vacuum and further increase of velocity, until a limit is reached by the increased resistance of flow. These facts have been taught by experience to all builders who endeavored to reduce the cooling surface of otherwise efficient types of condenser.

I now turn to the rate of condensation per square foot. Mr. Orrok again refers to record rates obtained by experiments under certain conditions. I think I have dealt with these and had better speak in figures, asking Mr. Orrok to point out to me any condensing plant in practical operation, "for turbine and cooling-tower conditions," i.e., 80 degrees Fahrenheit cooling water and an average vacuum of 28 inches on a 30-inch barometer, between the cleaning times, showing a rate of condensation of more than 12 pounds of steam per square foot and per hour. I will even go farther and allow 75 degrees Fahrenheit cooling water, although this is not good practice and calls for quite enormous towers.

Referring to Hausbrand's book on "Evaporating, Condensing and Cooling Apparatus," I, of course, know this. The author has had great experience in apparatus for distilleries, sugar factories and others, but has probably never built a steam-condensing plant or a cooling tower. I should like Mr. Orrok to try to design such plants from this book, and I am sure he will have some fun doing it. I can also assure Mr. Orrok that I know the other great book, that of Weiss, which is nearly always quoted when condensing matters are discussed. This book has its great merits, but strangely enough hardly touches on the question of heat transference and, instead, dwells on the countercurrent principle to unbearable length, the result of this one-sidedness being some fallacious deductions referring to the capacity of air pumps. Professor Josse's paper has in the meantime been published.

In conclusion, I would say that from a scientific standpoint there is now sufficient information at hand to enable manufacturers to build efficient condensing plants. The surface condenser itself will hardly be subjected to radical changes as long as we have to adhere to straight cylindrical tubes. This is not so with the air pump, which for high vacua is open to many improvements. The greatest trouble, however, is the uncertainty about the amount of air to be handled. It is the air which makes condensing so complex a problem, as it not only affects the air pump, but the condenser also. The builders of condensers have to guarantee their plants for high vacua under unfavorable temperatures of the circulating water, without in the slightest way being protected against excessive air in the system.

A correct and reasonable guarantee for a certain vacuum should be based on the quantity of steam to be handled, the temperature of the circulating water and the amount of air carried into the condenser by the steam (or in the case of a jet condenser, by the water also). But as matters are standing, the estimate of the amount of air to be handled is an exceedingly rough one, and so are the methods to measure the air actually discharged from a condensing plant. A clause like, "Provided that the system is reasonably (or perfectly) free from air leaks," means, of course, nothing. Here is the point where scientific experiments on actually operating plants have to set in. If Mr. Orrok can help to this end his efforts will be greatly welcomed by the profession.

OTTO H. MUELLER.

London, Eng.

How Improve the Diagrams?

Last fall I took a week off, and not knowing just what to do, I thought of taking indicator diagrams. Among others I obtained those shown in Figs. 1 and 2. These diagrams were taken from a Reynolds Corliss cross-compound engine. The high-pressure cylinder was 20 inches in diameter, the low-pressure 42 inches in diameter; stroke, 48 inches. The boiler pressure was 150 pounds per square inch; receiver pressure, 15 pounds; the revolulutions per minute, 107; scale of spring for high-pressure, 80, and of the low-pressure cylinder, 15.

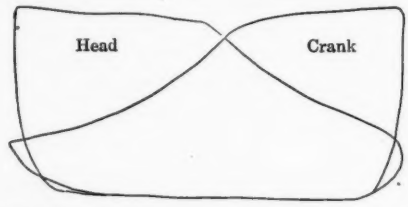


FIG. 1

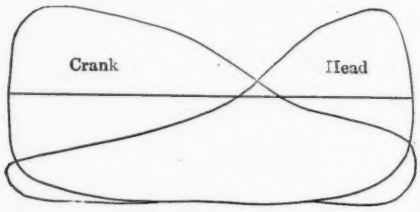


FIG. 2

I should like to have the readers give their opinion of these diagrams, as to what changes would be necessary to make the engine give a better looking diagram.

LINDON A. COLE.

Blacklick, Ohio.

Boiler Efficiency

In the issue of February 2, page 239, there appears an article giving certain results relative to tests of run-of-mine coal as compared to briquets made therefrom, which is an abstract from a recent bulletin of the United States Geological Survey, in which it is stated: "In all classes of service involved by the experiments, the use of briquets in the place of natural coal appears to have increased the evaporative efficiency of the boiler tested."

The publication concerns itself more particularly, of course, with the matter of briquets, but the statement in the paragraph quoted is so far in error that it seems desirable that attention be called to it. The question is, how can the change of fuel affect the efficiency of a boiler? A boiler is efficient due to its design, the material entering into its construction, etc., and the purpose of the boiler is to abstract the heat from the gases flowing over it. Its ability to do this is dependent upon certain features of shape and arrangement of parts, and the efficiency of a boiler as a heat abstractor cannot be altered without changing the shape of the apparatus. If we have a plain cylindrical boiler without tubes in it, and we alter it by placing tubes therein so that the gases also pass through them, we have increased the efficiency of the boiler materially, but if in one case it should have coal burned under it and in the other briquets, the efficiency of the boiler would in nowise be affected, because in each instance it would be the same plain cylindrical boiler.

In my opinion it is well to call attention to these features, as it tends to a better understanding of the matter of boiler performance.

A. BEMENT.

Chicago, Ill.

Power Plant Records

In the February 2 number was an article on "Power Plant Records," by Mr. Bogart, which interested me greatly. I get all my meter readings at 7 a.m. The coal is conveyed to the boiler house on a small car, weighed on track scales and totaled once a day. All records are kept on a properly designed report sheet. By using a recording wattmeter and a water meter it is possible to come very close to what the boilers are doing. As to the live steam we are using we can only guess at that. We use recording pressure gages, a recording voltmeter and a recording meter on the heating main. Meters on the air compressors would help some. With the appliances I have, it is interesting to see the changes in the average evaporation, due to one cause or another.

A. G. MACFARLAND.

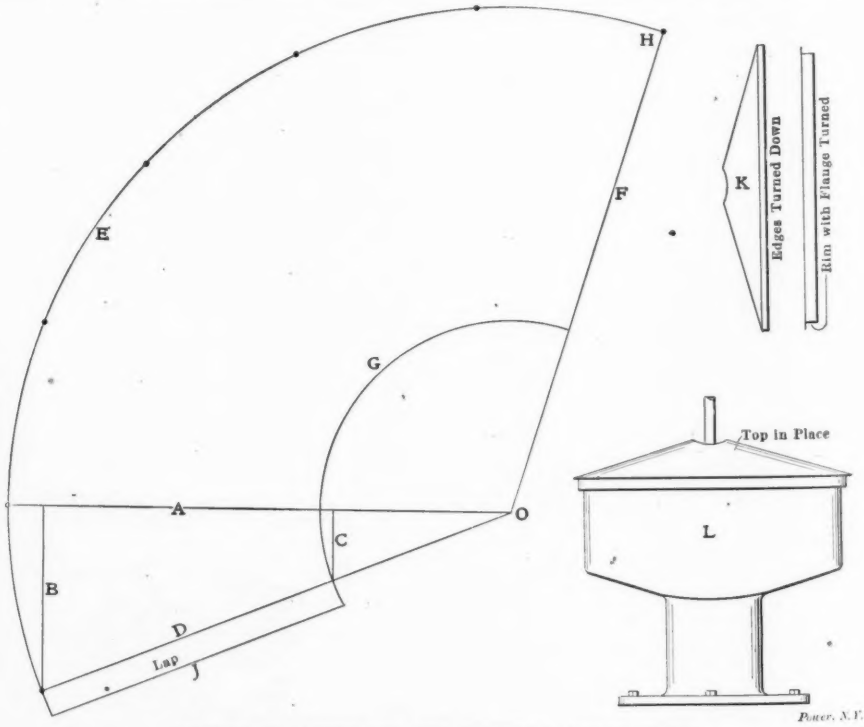
Ilion, N. Y.

Making Dashpot Covers

The accompanying illustration shows how I made covers out of heavy tin for my dashpots, to keep out dust and dirt. The cover was made large enough to fit nicely over the top of the dashpot. The hole in the cover was made large enough to leave room around the rod so the air can pass out when the dashpot is on the upward stroke, without lifting the cover. An explanation of the method used in making the dashpot cover is as follows:

First draw the line *A*. Then draw the line *B*, equal to one-half of the diameter of the cover, and at right angles to *A*. Lay off the length or hight desired from *B* on *A*, and draw the line *C*, at right angles to *A*, equal to one-half the diameter of the top. Then draw the line *D*, from *B* to *C*, up to *A*, cutting it at *O*. Set the dividers equal to the line *D* from *O* to *B*, and placing the stationary leg at *O*, draw as much of the circle *E* as necessary. Then set the dividers equal to the distance between the lines *D* and *A* in the circle *E*, and space off six times this distance on the circle *E*, as shown. From the point *H* draw the line *F* to the point *O*.

Next set the dividers equal to the distance between the line *C* and the point *O* on *D*, and draw the circle *G* to the line *F*.



METHOD OF LAYING OUT AND CUTTING DASHPOT COVERS

If lap is desired to fasten the ends together, add this on by drawing the line *J*, parallel to line *D*, at a distance equal to the required lap. Then by cutting along the lines *F*, *E*, *H*, *D* and *G* the cover is ready to be put together. A rim is then soldered on as shown at *K*. At *L* is shown the cover as applied to the dashpot.

CHARLES H. SPARBER.

Fertile, Minn.

A Harmless Scare

That a good engineer may make mistakes is not to be disputed, and often these mistakes are amusing, rather than serious. A case in point occurred recently where a gas engine and producer had been installed in the basement of a department store in the heart of the business district of a Western city. One of the requisites of this installation was that there should be no noise from the exhaust of the engine, and to accomplish this end, a large tank, buried in the floor of the engine room, had been used for a muffler, and from this tank a 6-inch exhaust pipe extended up seven or eight stories to the roof of the building. The plan worked nicely, the exhaust was quiet, and for months the plant ran beautifully.

The engine was rated at 75 horsepower and was started with compressed air. One morning the engineer turned on the air as usual, the engine began turning over and drew a charge of mixture into the cylinder. The charge did not ignite, however, and the mixture was expelled non-ignited into the exhaust muffler. This was repeated several times. The engineer was at a loss to understand why the engine did not start, and kept turning it by compressed air until it had made 20 or 30 revolutions, and the unexploded charges drawn through the engine and pumped into the exhaust system had become sufficient in volume to fill the exhaust tank and the entire pipe line to the roof. In the course of his hunt for the trouble, the engineer discovered that he had neglected to turn on the switch connecting the magneto with the igniter. This he promptly did, and the engine "picked up" all right on the next revolution.

The engineer, being in the engine room, felt no disturbance beyond a slight thud when the first charge of burnt gas was exhausted into the muffler. On the other hand, those on the outside of the building were treated to an explosion that sounded like the bombardment at Manila and which shook the entire section of the wholesale district, calling out both the police and fire departments. Patrol wagons rushed hither and thither, the police dreaming of anarchistic bombs and the fire department hunting for a bursted boiler with its attendant horrors. The location of the noise was traced to the block in which the engine was, and the police and firemen, searching the buildings, finally arrived in the engine room, where they found the engineer placidly going about his business. He insisted that there had been no explosion from his engine; he had heard nothing at all, and there was nothing to credit up to him. Since then, however, he has been very careful to throw the switch before starting his engine, on the basis, to paraphrase the old saw, that an ounce of prevention is better than a visit from the police and fire departments.

G. P. RALPH.

Chicago, Ill.

Safety Valve Formulas

In the paper upon safety-valve capacity, contained in the March 9 number, I gave briefly the results of two extended series of tests, one upon safety-valve lifts and the other upon the coefficient of steam discharge in safety valves. The omission of a complete table of the former results has led to a serious misconstruction of them in the editorial in the same issue, in which they are quoted. In an endeavor to correct this, the results are here given with a little more detail:

The lifts at popping point of the seven 4-inch stationary-type valves of different design set at 200 pounds were 0.064 inch, 0.031 inch, 0.056 inch, 0.94 inch, 0.094 inch, 0.082 inch and 0.137 inch. Of the six 3½-inch muffler locomotive valves, set also at 200 pounds, the lifts at the popping point were 0.072 inch, 0.040 inch, 0.076 inch, 0.065 inch, 0.051 inch and 0.140 inch.

Inspection of these figures indicates, as by far the most important conclusion, the fundamental necessity that an adequate formula for rating safety-valve capacities must include a specific term for the valve lift. A necessity which arises from the fact that the great variation of over 300 per cent. in the lifts of the same-sized valves for the same pressure makes the assuming of any single valve for the lift, however carefully selected, an assumption liable to large error.

There are two hypotheses in the editorial: First, "that the lift * * * * is around 3/32 inch (0.094) for all valves in normal condition," and, second, that "any maker will guarantee a valve of any size to lift 3/32 inch (0.094 inch) when the valve pops, and to stand at that hight so long as the pressure is maintained." Irrespective of what safety-valve makers may be able or care to guarantee, the error of these assumptions as applied to valves as they exist and are actually put upon boilers is very great, which is apparent not only from the tests cited, but from the figures given by manufacturers themselves.

The advocacy of "low" lifts and the generally admitted existence of so-called "high" lifts, brought out in the discussion at the A. S. M. E. meeting, indicate further that a uniformity of lift results for the same size of valve not only does not exist, but is not sought for nor desired by the different manufactuers of safety valves. In view of this lack of uniformity, it would seem wiser to leave the determination of valve-lift values to the manufacturers themselves as essentially their own proposition. On the other hand, the question of valve-capacity rating is of vital importance to and must be considered by users, insurers, designers and owners of steam boilers.

Obviously, in a formula as suggested in the editorial, there can be no distinction corresponding to the great existing variation of valve lifts and under such a formula valves with 0.031-inch lift must receive the same rating and specification as valves with 0.094- and 0.14-inch lifts. In assuming a given lift, as there done, not only are the valves whose lifts are less than the assumed value overrated, resulting in the liability of over-pressures, but using it with valves whose lifts are greater than that assumed a boiler would be over-safety-valved, which magnifies the strain to the boiler due to this cause, if such exists, as suggested in the A. S. M. E. meeting. And these errors resulting from the use of a formula similar to that in the editorial are not small enough to be negligible, for with the most carefully selected assumed average lift they amount to as much as 150 per cent. each way.

The only adequate method, therefore, is to require manufacturers to state definitely the lift of their valves, mark it upon them and then rate them accordingly, by the use of a capacity formula which includes a term for this lift. Adopting a rule as suggested in the editorial and leaving manufacturers to qualify under it with unknown lifts, which in cases are but one-third of that assumed, would mean a deliberate throwing away of the evidence of valve-lift research recently conducted by a number of independent parties, including the United States Government at Annapolis.

The inadequacy of such rules as that suggested in the editorial has already been recognized by the safety-valve committee of the American Railway Master Mechanics' Association, which in its report of May 18, 1908, cited a variation in the safety-valve lifts of nine different makes of valve of from 0.03-inch to 0.15-inch, and recommended a capacity rule (based upon heating surface) which includes a term for the effective area of valve opening, obtainable only by determining the valve lift.

And last, the added simplicity of the rule as given in the editorial over that containing a term for the valve lift is very slight, especially if the constant recommended in the latter is changed but 5 per cent. in the conservative direction, giving

$$D = 0.01 \times \frac{W}{1 \times P},$$

while that of the editorial is

$$D = 0.1 \times \frac{W}{P}.$$

PHILIP G. DARLING.

New York City.

Gas Power Blowing Equipment at Gary, Ind.

Essential Mechanical and Operative Features of the Indiana Steel Company's New Gas Engine Installation for Blowing Furnaces

The almost exclusive adoption of gas engines at Gary for blowing the furnaces, as well as for electric service throughout the mills, represents the first decisive step in American steel manufacture toward full recognition of the development in gas-power equipment which has been going on for the last ten years. Outside of German practice, which has been so conspicuously successful, the only forerunners of this great undertaking in America are the gas-power plant of the Lackawanna Steel Company, at Buffalo, and the more or less experimental application by the United States Steel Corporation in the vicinities of Pittsburg and Chicago. It is not to be expected that so important a property as the Gary works would permit of the least uncertainty in the matter of gas-power application if such uncertainty existed, and it is, therefore, fair to assume that the experience of the United States Steel Corporation has been signally successful.

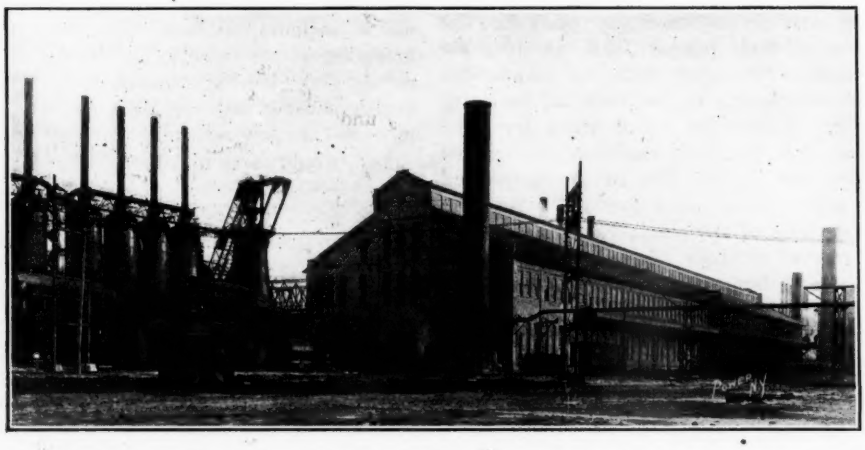


FIG. 1. GENERAL VIEW NORTH END OF GARY WORKS, NOS. 11 AND 12 FURNACES, WITH NO. 3 BLOWING HOUSE

No. 3 Gas Blowing House

In a detailed study of so large a property, the subdivision of the work into the most important groups becomes imperative, and following the general order in which the Gary property has been completed, the No. 3 gas blowing house calls for first consideration. The first of the three gas-power houses to be placed in commission is typical of the general construction employed in the No. 1 and No. 2 blowing houses which are to follow. The systems of blast control, air starting, ignition, water supply, lubrication and organization of operatives are the same as contemplated for the other plants.

This No. 3 blowing house is located at the extreme northern end of the power property, next to the lake front, and is shown in the general photograph, Fig. 1, which embraces all those parts of the furnaces and contiguous buildings which have been put into operation. This view includes, at the extreme left, Nos. 11 and 12 furnaces, which are in operation, preliminary washers and the No. 3 blowing house in the foreground. At the extreme right is shown the storage-battery building and the north end of the electric-power house, which will next be put into commission and the general features of which have been described in previous articles. The third group of furnaces, Nos. 9 to 12, and the first to be put in operation, served by the No. 3 blowing house, will be duplicated in the first, second and fourth groups now under erection, Nos. 5 to 8 to be served by No. 2 blowing house and Nos. 1 to 4 by No. 1 blowing house, these being provided for at the southern end of the property. Thus there will be virtually three independent groups of furnaces, of which the northern is in every sense typical. These groups will only be connected by means of a 5-foot gas main extending between the various blower houses and operating somewhat as an emergency tie line. The air-blast lines for each group are, however, not interconnected, as in the case of the gas supply. Practically every operating function of these groups is, therefore, independently complete with the exception of the low-service water supply and the air-compressing plant by means of which the gas engines are started, this being located at a central point in the electric station, as later noted.

The general assembly drawing, Fig. 6, shows in plan and elevation one of the eight gas blowing units, together with air blast, water, gas, air, exhaust and compressed-air mains. Each of these will be referred to in detail later. Figs. 3, 4 and 5 show general views from both gas and air ends of the end units. The building is laid out with 26 bays, 23 feet wide, aggregating about 600 feet in length and 104 feet in width. All the units are spaced 46 feet between centers, including two steam blowers.

It is to be expected that in so large an undertaking some steam reserve would be installed, which is the case, and, moreover, steam is a necessity for starting the furnaces. For each group of furnaces there is a plant of 16 water-tube boilers which supplies steam to a pair of steam blowing engines in No. 3 blowing house; a pair of 2000-kilowatt steam turbines in the electric house; a steam-turbine-driven pump in the pump house; fire pumps; hydraulic pumps and steam for miscellaneous purposes around the plant, such as steam coils for oil-settling tanks and for preventing the holder, preliminary washers and gas valves in the various distributing lines from freezing during cold weather. This boiler house is fitted for burning blast-furnace gas. This same steam reserve will be provided in each of the blowing houses to be built, as well as the electric houses, so that nothing short of a general disablement will cause the ever-dreaded stoppage of blast at the furnace tuyeres.

The blowing house contains eight gas blowing units aggregating in capacity 265,000 cubic feet of free air per minute, and in addition, two 45,000-cubic foot steam units. The layout contemplates that for each pair of furnaces three gas units will be required with a spare, the steam unit being held entirely in reserve. These 450-ton furnaces each require 44,000 cubic feet of blast per minute. As each blowing unit supplies 33,000 cubic feet of free air per minute the proportion of capacity will be evident. For the returning gas a cleaning plant capable of handling nearly 176,000 cubic feet per minute is required. The gas for the hot-blast and steam-boiler plant is only partially cleaned in the dust catchers and preliminary washers, which

remove the greater part of the heavier foreign matter.

It is estimated that about 30 per cent. of the blast-furnace gas produced is required in the stoves, leaving 70 per cent. available for outside purposes, or deducting 10 per cent. for boilers and loss in washing, somewhat over 60 per cent. for gas power. Consequently the secondary cleaning plant of tower and Theisen washers needs to take care of only about 105,000 cubic feet per minute. This corresponds to the capacity of seven tower and Theisen washers, leaving one unit of each in reserve. This amount of purified gas, which now averages about 95 B.t.u. per cubic foot and will approximate 90 B.t.u. after the furnace burdens have assumed their normal condition, will develop 66,000 indicated horsepower in gas-engine cylinders well loaded, which is more than sufficient to operate the blowing house and half of the electric house. The tower washers are a modification of the Zschocke type.

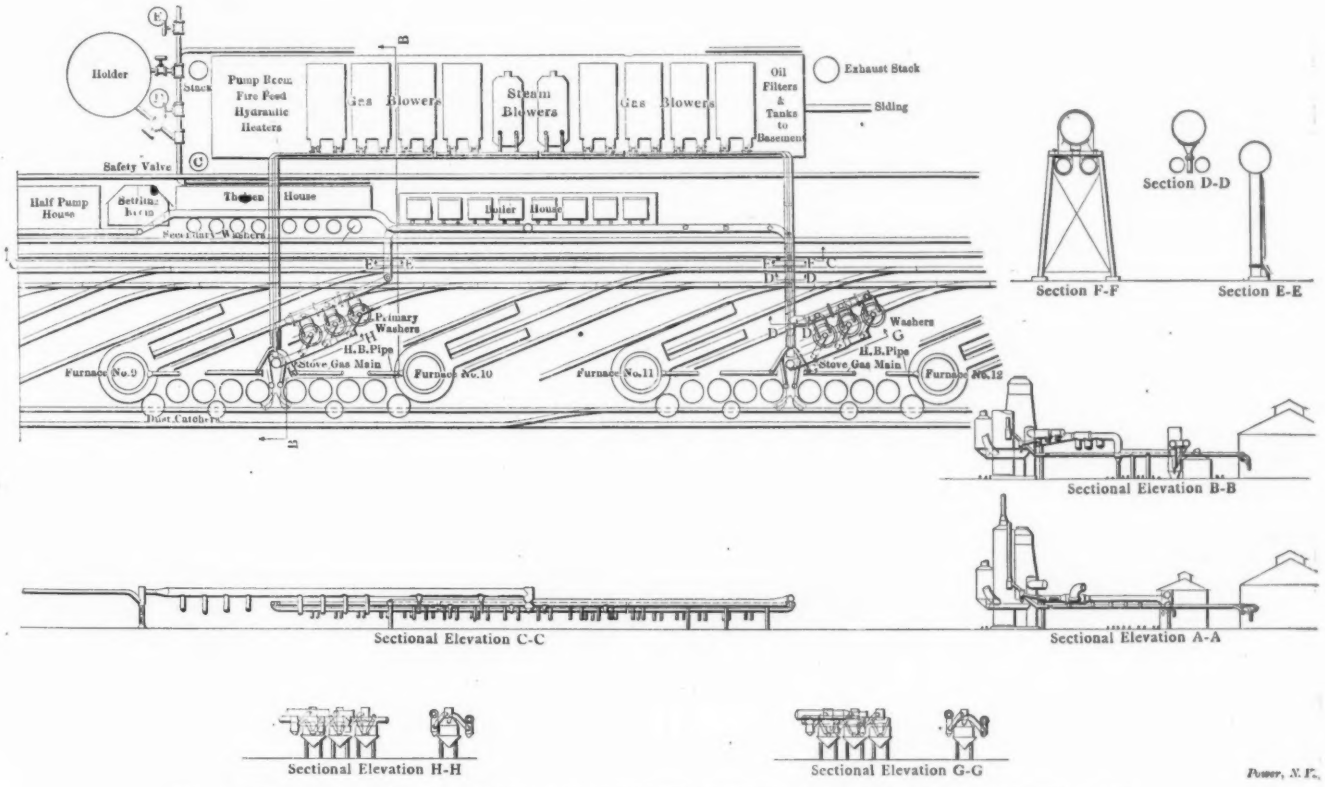


FIG. 2. GENERAL VIEW OF NORTH GROUP OF FURNACES, SHOWING ARRANGEMENT OF WASHING PLANT, BLOWING HOUSE, PUMP HOUSE, ETC.

The Blowing Unit

As the details of construction of the Westinghouse horizontal, double-acting gas engine have been described in previous articles*, it is only necessary to review here certain of the essential features which have the most important bearing on the successful operation of the plant as a whole. The general disposition of parts is clearly shown in Figs. 4 and 5; Fig. 4 being taken from the power end of the near engine and Fig. 5 showing more clearly the Slick tub and driving gear. These large units are set down to the floor level with openings 17 feet wide between supporting piers to provide access to the exhaust valves. This works out quite favorably, giving a depressed floor between the two sides, 5 feet below the main floor, with galleries running along the cylinders at the floor level, as shown in Fig. 7. This avoids entirely the bad feature of an exhaust-valve pit, which was encountered in early attempts to locate the engine at the floor level. Underneath this depressed floor, which is of steel plate, run the exhaust-pipe lines.

The engine itself is in all respects identical with the builder's standard design for a 2000-kilowatt electric unit. It works on the four-stroke cycle, and is double-acting, with a compression pressure of 200 pounds at full load. No attempt at special methods of scavenging or constant compression has been made, although the valve design permits of this to a certain degree, if desired. The lay shaft is located on the outside, supported by pedestal bearings independent of the engine. This arrangement avoids the use of spiral-gear drive for the lay shaft, which is driven by spur and bevel gears, each provided with a hunting tooth to equalize the wear and practically eliminate back lash. It will be noted that both the inlet and the exhaust valves at each end are driven from a single eccentric, as usual with the large Westinghouse double-acting engines. This gear permits setting the valves so that the exhaust and inlet periods overlap, which makes possible a more perfect cylinder filling than would otherwise be possible and also a certain amount of scavenging due to the inertia of the incoming and outgoing columns of gases.

The piston rods are interchangeable, end for end, so that in case of necessity they may be transferred from one cylinder to another. The pistons are secured in place by external nuts forced up and turned off flush with the piston face. The piston itself is cast in a single piece, symmetrical in section about both axes, and without chaplets, plugs, or internal ribs. Fig. 9 shows this construction. The core is supported from inside the opening, as shown. This construction places the inner wall or hub of the piston under direct compression, relieving the bending strains at the rod considerably. These rods are not cambered or otherwise compensated for deflection, which is barely discernible, and just suffices to keep the packing rings free. All rod packings are of the quadrant metallic-ring type, not water cooled, but lubricated by the force-feed pumps.

The air and gas piping are entirely separate from the cylinder body (see Fig. 6), approaching the valve chambers at the top from opposite sides, so that the mixing of gas and air is not possible until the

*POWER AND THE ENGINEER for April 28 and December 8, 1908.

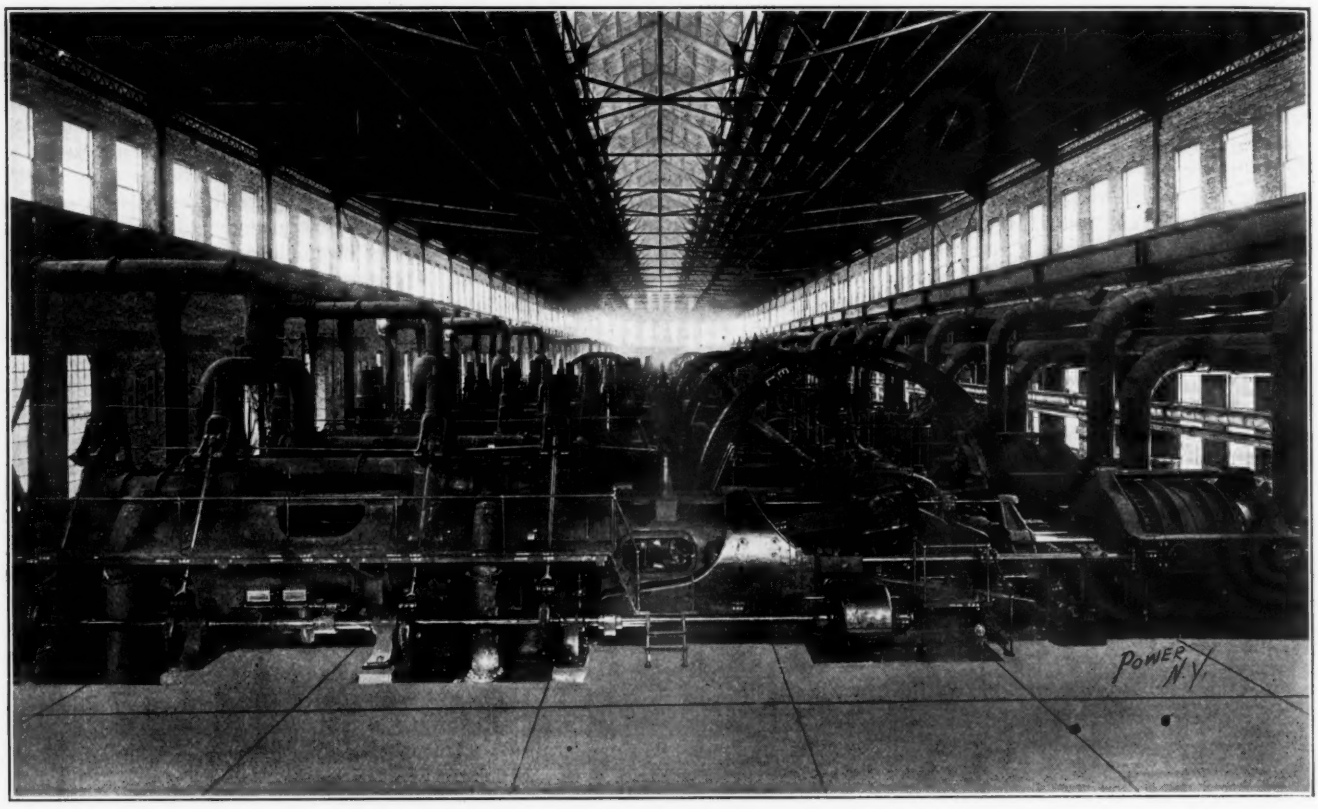


FIG. 3. GENERAL VIEW OF INTERIOR OF NO. 3 BLOWING HOUSE FROM SOUTH END

inlet valve is reached. Although Fig. 8 shows solid cylinder and jacket walls, they are cut apart at all openings and bushed.

Cooling System

Fully one-third of the cylinder jacket consists of a removable band around the center of the cylinder, so that easy access can be had to the remotest jacket spaces. The advantage of this feature has been demonstrated by previous experience of the builders with the clogging of cylinder jackets by deposits from muddy cooling water. A mud ring is provided at the bottom of each cylinder exhaust jacket which may be quickly slipped off without disturbing the exhaust-valve cage, thus opening the entire jacket space for clean-

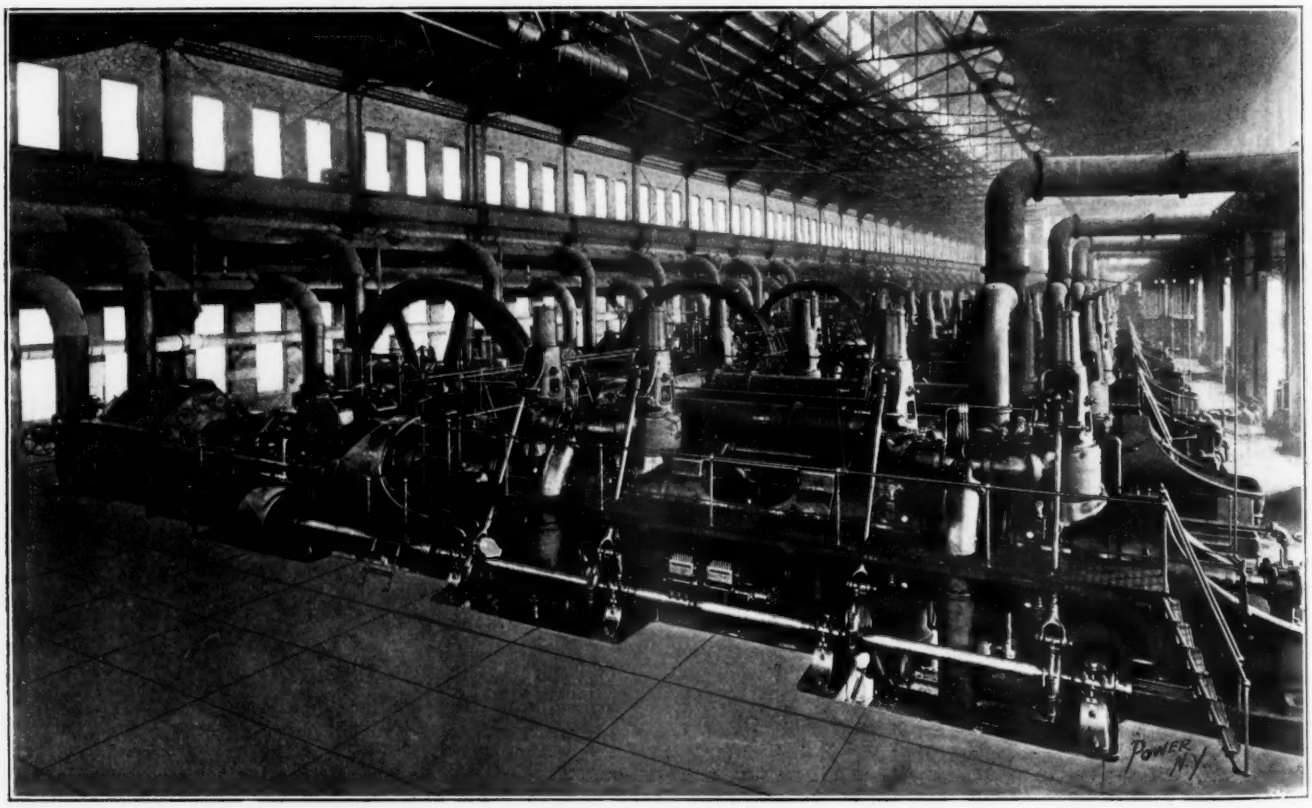


FIG. 4. GENERAL VIEW OF UNITS FROM POWER END

ing with a hose. Cooling water is provided at a pressure of about 35 pounds for all the parts from a 16-inch main running the length of the building. A single valve controls the supply to each side of the engine and plug valves in each water circuit are provided so that the rate of flow, once set, need not be changed. These separate circuits serve all the important parts, each having a visible overflow so that the quantity and temperature of the jacket water in any circuit can be determined at any time. Each exhaust-valve circuit has a separate overflow. Being insignificant in amount, the water is wasted, but other circuits are arranged in series as far as possible. Cylinder-jacket water enters first through the exhaust-cover chambers, escaping into the cylinder at the bottom, just under the exhaust port—the hottest part—ascending around the cylinder jacket to the top, where it overflows, always keeping the jacket full. To economize water farther, the pistons and heads are supplied in series on the countercurrent principle. After passing the front and rear heads of the forward cylinder in series, the warm water enters the piston rod at the middle crosshead, thence through the piston and out at the front end. In all cases, water enters at the bottom and overflows at the top of the chamber to be cooled so as to keep the parts full. This series system provides a fairly even temperature at all four packing glands, which would be impossible if both pistons were in series—one hot and the other cold. Telescopic supply pipes are used at the intake ends of the piston rods instead of knuckle joints.

Exhaust Pipes

The four individual exhaust connections for each cylinder enter a 30-inch exhaust manifold (one for each side) which communicates with an 8x10-foot brick tunnel running the full length of the building and discharging into a 100-foot stack at each end. This tunnel has an arched brick roof, but is not otherwise protected against the possibility of after explosions. All waste discharge water from the engine jackets drains into the exhaust tunnel (see Fig. 6) and serves to cool the exhaust gases and thereby to reduce their volume and consequently the back pressure on the engine. It will be noted from Fig. 6 that deflecting nozzles are provided at each entrance to the manifold, which gives the exhaust gases a definite direction and thereby reduces the resistance of exit. Means for sealing each of these manifolds while men are working on the engines is provided in the form of a dip at *D* which may be filled with water and thus operate as a gas-tight seal. A drain valve controls this seal, also a seal for the jacket overflow. During cold weather the engine exhausts are run dry in order to utilize the heat for warming the building.

Gas Supply

Along the west wall of the building a 7½-foot steel gas main rests on structural wall brackets and communicates to each blowing unit through a 24-inch supply pipe equipped with a gate valve and a pressure-regulating butterfly valve, as shown in Figs. 4 and 6. The latter is required to reduce the pressure of the gas delivered to the engine exactly to atmospheric so that air and gas may be drawn into the engine at the same pressure and thus have the same proportion, as determined by the respective inlet-valve settings. The butterfly valve is operated automatically by a small gasometer shown at the rear of the engine and in Fig. 10, which communicates with the supply pipe on the engine side of the butterfly valve. Similar butterfly valves located at the entrance of each inlet valve enable the operator to adjust the proportion of gas and air to any desired value, to suit the quality of the gas.

Air Intake

An especially neat feature is the method of taking in the air for the engines. For this purpose, a flue, or "riser," is built into the engine-room wall opposite each line of cylinders, and an open louver at the top gives free access to outside air. These louvers are protected by wire screens, as shown in Fig. 11. At the base of the flue is shown an explosion door directly anchored to the air pipe, which is intended to relieve the force of a back-fire, but these doors were not installed at Gary. They were finally deemed unnecessary, but if desired may be put in later. Owing to the large area of the intake duct, which is nearly three times that of the supply pipe to the engine, it is improbable that a back-fire would result in any damage.

Governing

Speed control is effected by means of a relay type of oil-pressure governor. The essential feature of this system is that the actual work of moving the large valves is accomplished by an oil-pressure cylinder working under a pressure of 50 to 60 pounds provided by a plunger pump driven from the engine lay shaft. The centrifugal governor is relieved of all work except operating a small pilot valve which controls the supply of oil to the working cylinder of the system. The oil pressure can always be noted at the engine gage board, and should the pump fail a small gravity accumulator serves to maintain pressure until reserve valves can be opened. In addition to the main governor, a centrifugal safety-stop device is provided at the rim of the flywheel which trips the main igniter switch at a predetermined overspeed and shuts down the engine.

Compressed-Air System

As previously mentioned, the compressed air for Nos. 2 and 3 blowing houses, as well as the electric-power house, is supplied from a plant of compressors in the latter building. These are 14 and 18 by 12-inch two-stage machines geared to 50-horsepower motors and each provided with automatic outlet valves which open at 200 pounds pressure. The general practice is to provide a number of steel storage tanks for compressed air, holding the majority of these in reserve in case of a breakdown of the compressing plant, but owing to the great length of the buildings at Gary, the somewhat unusual system of a single-pipe main of extra-large size has been employed. This main is 30 inches in diameter and extends the entire length of the building at the rear, beneath the operating floor. The nozzles leading to each side of each unit are welded to the main, and Van Stone high-pressure joints connect the various sections. Quick-throw valves are used only at starting and reinforced by 4-inch high-pressure gate valves.

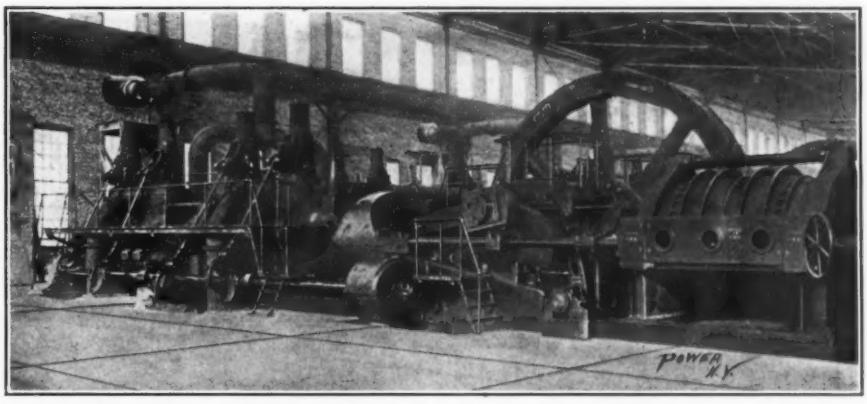


FIG. 5. GENERAL VIEW FROM BLOWING END

Ignition

So important a function as the ignition calls for reserve equipment. At the engine three igniters are provided in each combustion chamber, located at points in the cylinder almost equidistant, as shown in Fig. 8. All of these igniters are supplied through individual safety fuses, so

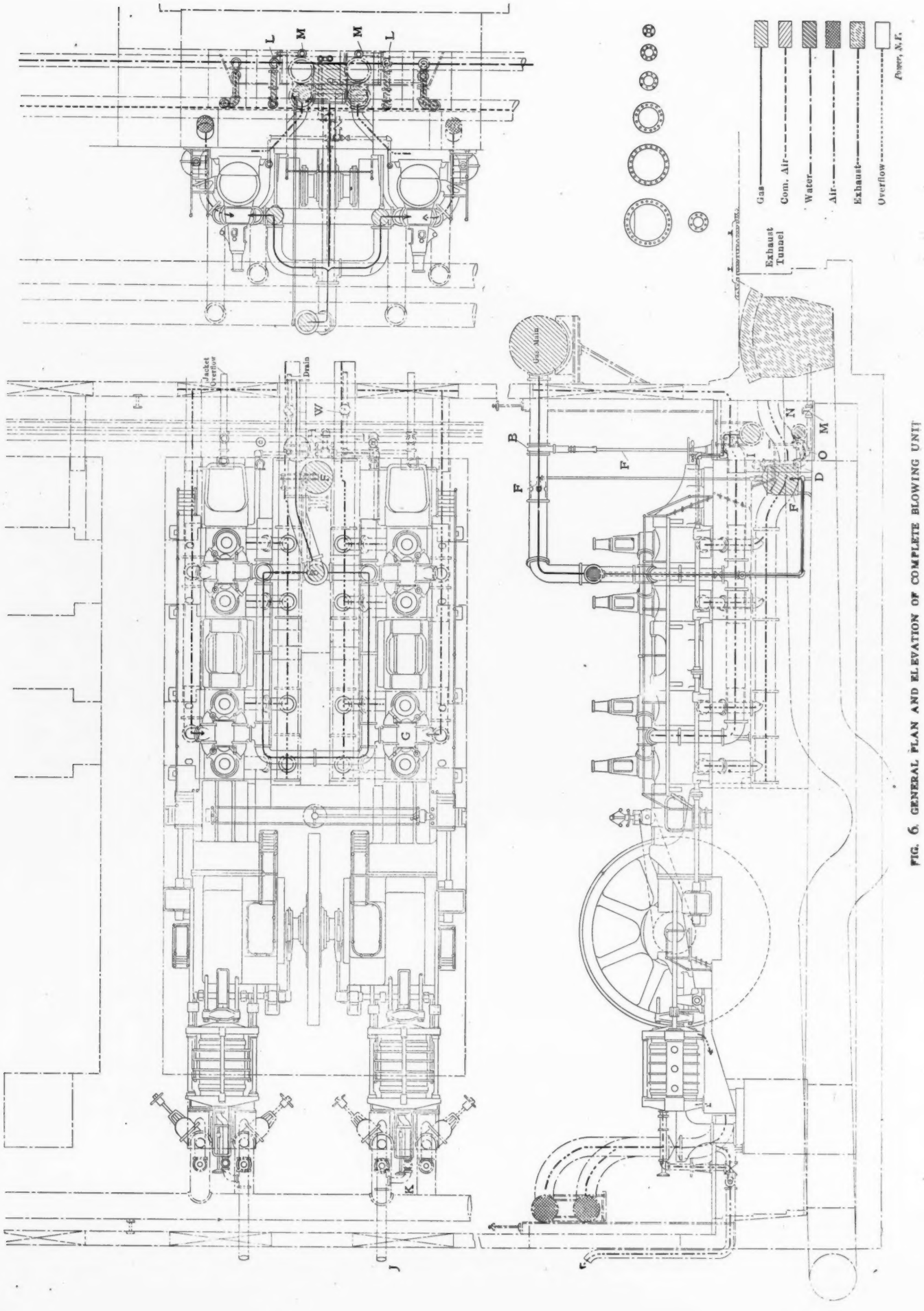


FIG. 6. GENERAL PLAN AND ELEVATION OF COMPLETE BLOWING UNIT

that a short-circuit of any one will not affect the others.

Both electrodes are insulated from the cylinder body so that a double ground is necessary to complete a short-circuit of an igniter. Grounding, however, usually occurs from sweating inside. Consequently, vents to the atmosphere are provided (see Fig. 12).

The make-and-break system is used exclusively on these engines. Although the igniter is standard with either mechanical or magnetic trip gear, the Gary engines are entirely equipped with the latter in order to avoid the excessive complications arising in the provision of three sets of igniters mechanically driven. The usual rotary timer, driven from the engine lay shaft, is used. It is thoroughly protected by an iron casing and runs in oil. By rotating the casing through a few degrees, as indicated by a graduated scale, the ignition may be advanced or retarded while the engine is in operation. The magnetic trip, which has recently been perfected, is shown in Fig. 12 in contact with the igniter stem. The electromagnet inside is of the so-called iron-clad type used for the field magnets of small bipolar dynamos and motors of rectangular outline. Being in series with the igniter, the magnet winding serves for the spark coil.

Ordinarily, the igniters receive current at about 110 volts from a small motor-generator set supplying each of the engine panel boards. The motor-generator is driven from the alternating-current bus-bars of the electric-power station. It is, of course, highly probable that this distant source of supply will sometimes be cut off by accident. In anticipation of such an accident connections have been provided with the storage-battery house nearby, and automatic apparatus is being constructed which will instantly throw the engine ignition circuits over to the storage batteries in case of trouble with the regular supply. And as the north and the south sections of the blowing house will be separate in this respect, the possibility of a complete shutdown is exceedingly remote. With all igniter wiring run in a protected conduit and thoroughly insulated with metallic junction and outlet boxes, the ignition system becomes one of the most reliable parts of the engine equipment. Whereas in the early days it was one of the most uncertain.

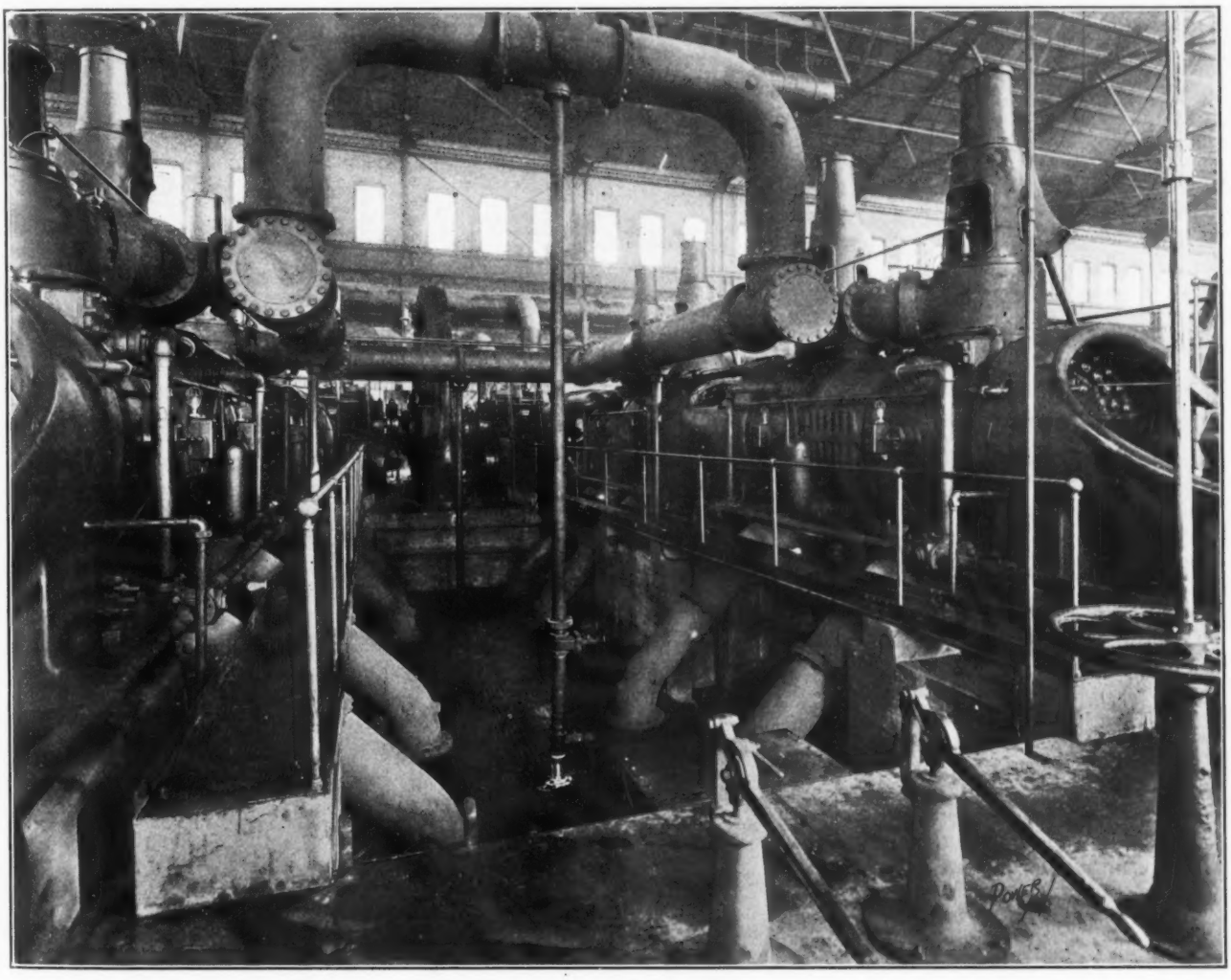


FIG. 7. VIEW BETWEEN ENGINE CYLINDERS

Lubrication

Both the cylinder and the engine oils are handled by automatic means, grease cups being used only on small, slow-moving parts, such as links, valve-gear pins, etc. In the design of the oiling system, provision has been made for the strictest economy in oil consumption and reliable feeding. For this purpose, the continuous-return system is used with settling tanks, filters and pumps in series. The system for No. 3 blowing house is equipped with a 2500-gallon storage tank resting upon the lower chords of the roof trusses, as shown in Fig. 4. From this point, oil is distributed to some thirty different parts on each blowing unit at a positive static head of about 25 feet. A single valve controls the supply to each side of each unit and the various circuits are served by four groups of sight-feed manifolds. When these are once adjusted for the proper rate of flow, they need not be changed, so that the work required to

maintain proper lubrication on these large engines is very small.

All the engine oil is returned to a common header leading to the basement filter plant, first reaching a group of three settling tanks 15x3¼x4 feet deep, where it is heated by steam coils and the sludge allowed to separate out (this sludge is caught and used in other machinery around the works). Next, a pair of vertical separating tanks removes the last traces of water. Finally the oil passes to a pair of special filters, from which it is pumped through a meter back to the roof tank. The fresh make-up oil is drawn from a 25,000-gallon tank which is large enough to take the entire contents of a railroad tank car (run in on the siding). As a precaution, a second 25,000-gallon tank is provided for overflow or storage.

Cylinder lubrication is taken care of by automatic force-feed pumps driven from the engine lay shaft and embodying the special feature that the eight individual circuits leading to various parts of each engine cylinder (including rod packings and exhaust-valve stems) are accurately timed so that oil is delivered into the cylinder only just before the end of the exhaust stroke. This allows two complete strokes of the piston before combustion takes place, during which the oil is effectively spread over the surface of the cylinder. The result of this system is that oil is injected only in small quantities and at the most effective moment. The cylinder-oil circuits run about 12½ drops per minute on the large engines, at full speed; the packings take somewhat more and the exhaust-valve stems about half that rate. It is contemplated in the completed plant to serve all of these cylinder-oil lubricators (32 in number) from a central point, putting a small meter in each feeder line to determine the rate of oil consumption. The oils used at present are "Red Engine" oil and "Diamond A" cylinder oil, both mineral oils.

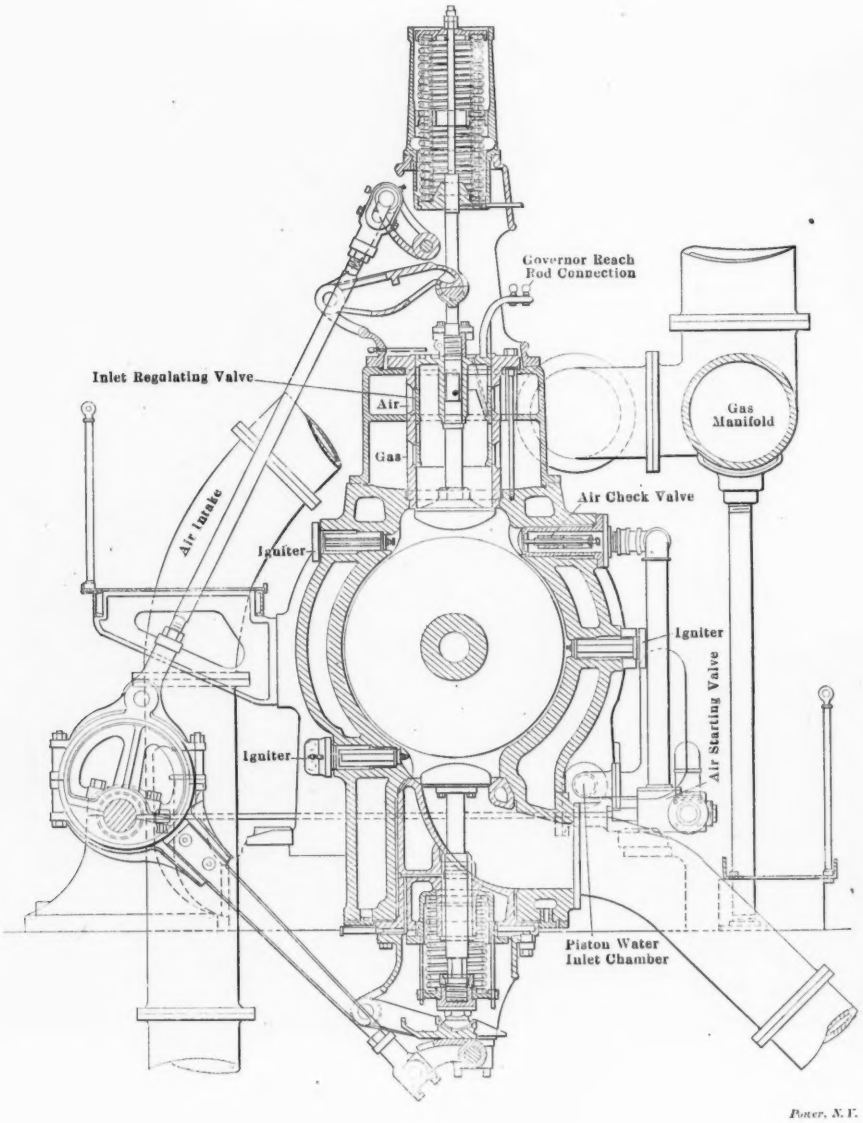


FIG. 8. DETAIL CROSS-SECTION OF GAS ENGINE THROUGH VALVE CENTERS

Gas Cleaning

This plant differs from those in the Pittsburg district in that the closed-top type of furnace is employed, that is, with no explosion door. All of the large piping is designed to withstand the maximum pressure which has been found to be produced by the explosion of a perfect mixture of blast gas and air uncompressed. Relief vents are, however, provided at several points in the open water seals of the primary, secondary and Theisen washers, so that an explosion in the furnace not damped out in passing through the tortuous passages of hot-blast stoves and piping would be relieved at one of the above-mentioned vents.

The dust catchers are of standard construction, but the primary washers are an improved type of Mullin washer, consisting of a central conical distributor suspended about 1 inch above the surface of the water, which is maintained at a constant level by an open overflow. The

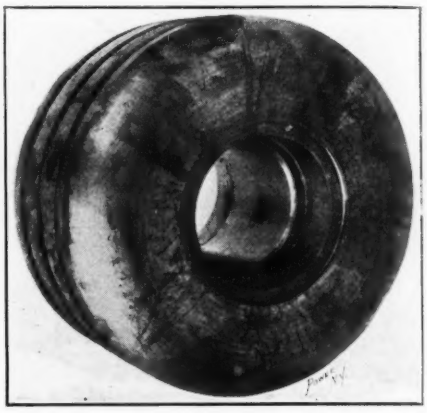


FIG. 9. 42-INCH ONE-PIECE GAS-ENGINE PISTON

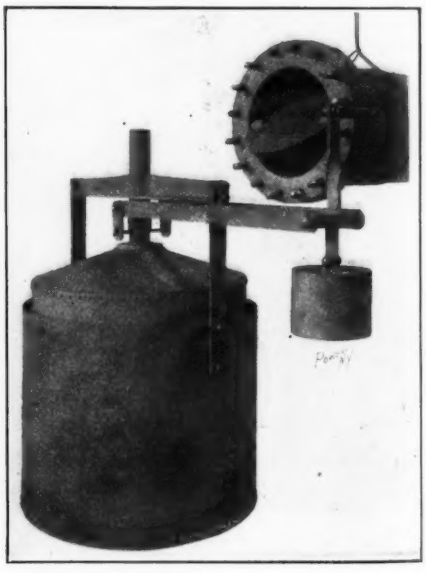


FIG. 10. GASOMETER PRESSURE REGULATOR SHOWING METHOD OF OPERATING BUTTERFLY IN GAS INLET

edges of this cone are deeply fluted, resembling in plan the shape of a starfish, so that a relatively great surface is presented to the gas, which is forced to spread out in a thin sheet over the surface of the water. Here the greater part of the suspended dust is deposited and drawn off below. In the tower static washers the gas is forced to ascend through a latticework continuously wetted with Körting sprays. It is also passed through several sheets of falling water obtained by conical baffles arranged in series at the base of the washer, replacing the individual baffle washers usually provided. In the Theisen washer house, final cleansing is accomplished, and the gas delivered to the mains with only 0.02 of a grain of foreign matter per cubic foot of gas. This is ample for gas-engine work, and actually exceeds the purity of the air at times at the engine intakes in the Pittsburg district. A similar cleansing plant at the Bessemer works has shown gas as clean as 0.002 grain at times, averaging 0.02 grain, while a slip in the furnace increases this considerably.

All of the overflows from the water seals of the primary tower and Theisen washers are returned to settling basins 20x40 and 12 feet deep, arranged so that the heavier material has an opportunity to settle out and may be reclaimed. A central division wall divides each basin into two compartments, one of which may be in use while the other is being cleaned.

As the Theisen washers normally deliver gas at 5 to 7 inches pressure, it is evident that if a break should occur in the supply main or its own water seal there would be danger of air being pumped into the holder, resulting in an explosive mixture. To prevent this, a large butterfly valve is installed between the Theisen washer house and the holder, which may be closed in such an event while the holder would then receive gas through the main from the blower house below.

In case the holder should leak or otherwise be out of order, large gate valves, geared down for hand operation, are installed in both the inlet and the outlet risers with a third valve in a bypass between so that the holder may be entirely cut out of service, the gas system then relying on the holder below, at No. 2 blowing house. Another butterfly valve in the holder-intake line is arranged to close automatically when the holder has reached its upper limit.

Operating Force

Much of the ultimate success of the Gary installation depends directly upon the efficiency of the operating force. Although so many of the more perfunctory operations have been taken out of the hands of the operators by the use of automatic appliances, yet a high order of intelligence is required in the few men intrusted with the care of the plants. These men must use their heads more than their hands. It may be supposed that so large a plant would require an army of men to operate it, but such is not the case. In normal operation, the No. 3 blowing house will be in charge of a chief engineer for

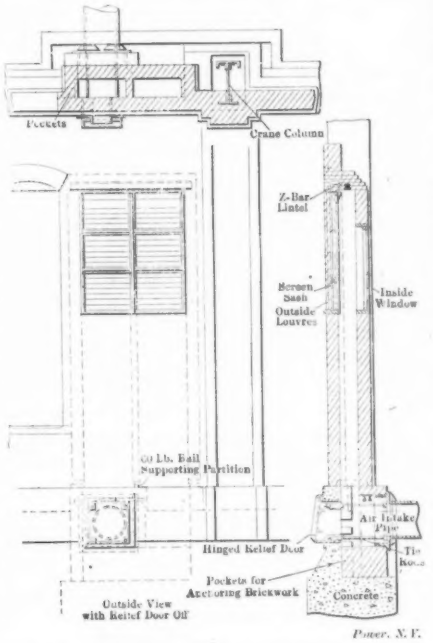


FIG. 11. DETAIL OF AIR-INTAKE LOUVERS

each operating watch. Each engine crew will consist of an engineman and two oilers; the oilers will handle the blast valves during furnace operation, and the water, gas, oil and air valves when starting up, with the engine driver in direct charge at the throttle. This makes a

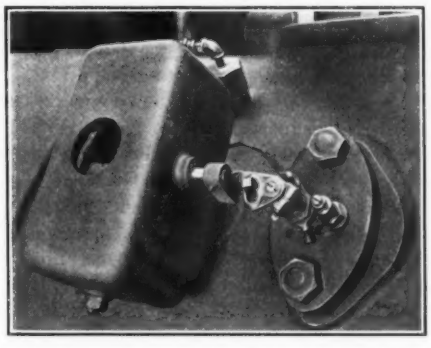


FIG. 12. IGNITER AND MAGNETIC TRIP IN POSITION ON ENGINE

power-house crew of about 20 men for handling 25,000 horsepower in gas engines. Considering that much of the actual work occurs in operating the valves of the blower, the amount of labor required for these engines is small, and in the case of the electric-power house even this might be reduced.

DATA ON NO. 3 BLOWING HOUSE.

Size of building	104x598 ft.
Foundation	3 ft. concrete monolith on sand
Hight of building to crane rail	28 ft.
Depth of basement	12 ft.
Bays (26)	spaced 23 ft.
Engine centers, spaced	46 ft.
Cylinders, center line to center line	23 ft.
Length of blowing unit over all	87 ft.
Width to center of gear case	38 ft.
Hight to top spring cages	14 ft. 10 in.
Elevation center line of engine	4 ft. 8 in.
Diameter of flywheel	24 ft.
Diameter of cylinders	gas 42 in.; air 68 in.
Length of stroke	54 in.
Main bearings	54 in. x 30 in. diam.
Crank pins	16 in. x 17 in. diam.
Piston rod	12¼ in. x 20½ ft.
Bore of piston rod	5½ in.
Depth of water jacket	4 to 5 in.
Ratio of crank to connecting rod	5½ to 1
Main shaft	21⅛ in. and 34 in. diameter
Piston speed; blower, 675; electric,	750 ft. per min
Compression, per sq.in. maximum	200 lb.
Piping, air and gas at inlet	16 inches
Piping, leaders	22 inches
Piping, exhaust at engine	20 inches
Piping, gas supply leader	7½ ft.
Piping, exhaust headers	30 inches
Piping, blast main	42 inches
Piping, blast risers	28 inches
Piping, water main	16 inches
Piping, compressed air main	30 inches
Rating of unit, free air per minute	33,000 cu.ft.
Rating of unit, maximum speed	75 r.p.m.
Rating of unit, delivery pressure	18 lb. per sq.in.
Maximum rating (28,000 cu. ft.)	30 lb. per sq.in.
Corresponding engine capacity (rated max.)	3400 to 3900 i.h.p.
Capacity of electric engine, prod. gas (84 r.p.m.)	3700 to 4200 i.h.p.

New York Civil Service Examinations

The New York State Civil Service Commission announces the following examinations to be held on March 27 next:

Assistant steam engineer, State and county hospitals and institutions; $40 to $50 per month and maintenance when employed in institutions. Candidate must have had two years' practical experience as machinist, boilermaker, steamfitter, oiler, fireman, engineer or electrician, including at least one year in the operation of stationary engines or electrical machinery. Subjects of examination and relative weights: Practical questions on the operation and repair of steam engines, boilers, steam-heating apparatus and electrical machinery, 6; experience, education and personal qualifications, 4.

Chief engineer, Westchester county court house; $1500. Open to legal residents of Westchester county only. Candidate must have had at least five years' experience as machinist, boilermaker, fireman, oiler, assistant engineer or engineer, including at least two years as engineer of stationary engines and electrical machinery. Subjects of examination and relative weights: Practical and theoretical questions upon steam heating, steam and electrical machinery and engineering practice, 6; experience and education, 4.

The commission recently issued a new form of application for competitive examinations, and candidates are advised not to use blanks of issues printed before October, 1908. The new blanks may be obtained by addressing the Commission at Albany, N. Y.

Safety Valves

Continuation of the Discussion of the Subject before the American Society of Mechanical Engineers at Its February Meeting

ALBERT C. ASHTON,

of the Ashton Valve Company, said that in his opinion what is most needed today is not necessarily a safety valve of greater capacity, but rather a better understanding of the proper proportioning of safety valves to boilers, for which there is no rule universally recognized and adopted. Mr. Whyte's paper touches upon this point and cites some recent tests made to determine the comparative capacities of pop safety valves on the market. While these tests show what the so-called new style high-lift valves will accomplish under certain favorable conditions, they do not prove that high-lift valves so made are a success in all applications. High lift is conducive to pounding upon the seat and to the lifting of water, and Mr. Ashton cited instances which had come to his knowledge where the use of valves having abnormally high lifts had been disastrous.

If high-lift valves were for a certainty an improvement, safety-valve manufacturers generally would change their designs, as can be easily done, and make nothing but high-lift valves. There may be some virtue in making valves with a lift a little higher than, say, 1/16 of an inch, but to make them with a lift of ⅛ of an inch, as appeared to be the trend of Mr. Darling's paper and of Mr. Lovekin's remarks, the speaker considered to be excessive and not advisable for general application.

Such being the situation, it was of little value, in his mind, to discuss the question of the capacities of safety valves, for whatever valve is desired the manufacturers can produce; but the speaker did hope that the society would interest itself in the question, which is of interest to the engineering profession, as to what is the best and most practicable schedule or formula that can be safely adopted for general use in determining the capacity of relief that safety valves should give on various-sized boilers at various pressures.

A. B. CARHART,

superintendent of the Crosby Steam Gage and Valve Company, devoted his remarks largely to springs. A safety valve should be designed by calculating the total spring load required to be exerted upon the disk when the valve is closed, then the suitable amount of further compression needed for vertical lift of the disk when the valve opens, with a reasonable allowance for a reserve of further possible free movement of the spring in compression, and thereupon determining the dimensions of the spring that will carry this load at its point of greatest efficiency, with due regard for flexibility, sensitiveness with accurate adjustment, and durability in service.

Within the limits of elasticity the deformation or deflection or compression is proportional to the force or pressure which produces it, and in a spring of given dimensions equal increments of force or pressure applied will produce equal amounts of compression. For example, if it requires a total load of 2000 pounds to compress a given spring having a total possible compression of one inch so that its coils are solid, with no farther deflection possible, a load of 1000 pounds would cause this spring to shorten one-half of that amount, or one-half inch, and each 100 pounds of load more or less would cause a shortening or lengthening of one-twentieth or 0.05 of an inch.

The compression of a spring at a given load is proportional to the number of coils, and the simplest way to increase the total compression or movement is to lengthen the spring. This increase of compression in proportion to the increasing number of its coils is independent of the total load which the spring will carry, and does not affect that question. If a load of 1000 pounds will compress a spring of certain diameter dimensions one-half of its total possible compression, or one-half inch, then a spring of the same diameter but twice as long and having double the number of coils would be compressed by the same load one-half of its total movement, or one inch. A load of 1500 pounds would compress either spring three-fourths of its total possible movement and likewise either spring would be compressed solid under a load of 2000 pounds. But the action of the two springs in safety-valve service would be very different, for the longer spring would have its power exerted through a greater distance.

The total amount of compression of a spring for a given load may be increased by increasing the number of coils of the same diameters and pitch and thus increasing the total free length; by reducing the cross-sectional area of the rod; or by enlarging the overall diameter; or all or any of these dimensions at the same time. If the spring be excessively long in proportion to its diameter and pitch it may bend or buckle instead of compressing in a straight thrust, and if the number of coils be too great the reaction of the spring sets up an oscillation, which not only permits but aggravates the undesirable and destructive chattering of the valve. If the spring be too short, not only is the reaction too sudden but the active free coils form a smaller proportion of the total length. It is not possible to distribute pressure at the ends of the spring exactly even upon the coils, and the spring compression is greater on one side than on the other, transmitting an undesirable side thrust to the disk guides. If the pitch is too steep the fiber stress upon the steel is enormously increased, and the rod is fractured or a permanent set takes place. If too many coils are put into a fixed length of spring there will not be sufficient free space between the coils to permit the necessary movement, and when the pitch is thus too flat the spring will have insufficient reactive power or force because of the inadequate strain or fiber stress put upon the steel. The spring must have sufficient force to make the valve open and close promptly and positively and keep the seat tight, not only to give prompt relief but to prevent the constant simmering and leaking which cuts and destroys the seats and permits the deposits of lime solids upon any exposed threads. The requirements of positive control and extreme lift are thus to a large degree contradictory.

Under no conceivable conditions of actual service can sufficient steam pressure be brought upon the disk of a pop safety valve to compress the spring so that the coils would be solid, if it has been in any way reasonably designed for its original fixed load; and the additional spring compression due to the lift of the disk to produce the valve opening to relieve the boiler is comparatively little, possibly 0.08 of an inch, or commonly and preferably less, and never under any conditions to amount to 0.18 of an inch or, say, 3/16 of an inch in the extreme.

If after the fixed-load pressure is reached the spring has still 15/32 of an inch of unused possible compression, of which less than 3/32 of an inch will be required to accommodate the desired lift of the valve, there will still be 12/32 or ⅜ of an inch before the spring will go solid; therefore, the valve spring can be properly designed to carry its set load at much more than half of its total free compression and more nearly to its solid condition than would be wise with a car spring. I believe it to be proper to proportion the spring so that the set load is carried somewhere near two-thirds or three-fourths of its total free compres-

sion, proportioning the length and dimensions of the spring so that the total free movement will be sufficient to make the remaining unused compression of the spring ample for the lift of the disk, and a safe margin beyond.

As in making boiler tests the head bolt may be set down until the spring is solid, and if the valve is fitted with a lever the spring may at times be compressed solid by that means, I would not consider it proper to use in a valve with a lever, any spring that would not safely take a solid test without showing any permanent set or strain.

As to the fiber stress, experience shows that springs may best be stressed from 60,000 to 75,000 pounds per square inch at the fixed load which should compress the spring to about 70 per cent. of its total possible free movement. The remaining movement should be three or four times the lift of the valve in opening. Springs wound of bronze are notoriously inefficient and unenduring, and their depreciation and permanent set at comparatively low fiber stress more than counterbalances any possible advantage of slow corrosion. The torsional elasticity and power depend not upon the tensile strength as much as upon the temper and resiliency. Therefore, some of the new alloy steels have proved disappointing for this service.

The spring must have sufficient compression to afford the amount of valve opening fixed upon as reasonable and practicable, yet be kept within the least amount of movement that will satisfy these demands, for every spring has considerable eccentricity, depending upon the pitch and proportion of the coils; and, under the increasing compression or extension as the valve opens or closes, the ends have a movement which may be likened in some degree to the actions of the free end of a fire hose under pressure. The side thrust due to this twisting and untwisting eccentricity is transmitted to the valve disk and increases rapidly with each fraction of increased lift or opening of the valve.

Large movement of the spring in compression is undesirable. It is but a necessary means to an end; an evil to be kept within minimum limits. It would be an advantage if a satisfactory discharge area of the valve could be attained with even less spring compression than at present. The large lift of the disk is not a measure of capacity, but of inefficiency, for that valve which releases the steam with the least proportional lift or spring compression is to that degree the more efficient for its purpose, and at the same time more safe and reliable. The greatest cause of the sticking of the valve, when it does occur, is not corrosion of the seat face, but the binding friction of the disk guides against the sides of the well or throat of the valve. This cocking or binding effect can be decreased by any modification of design which will reduce the diameter of the cylindrical guide, or which will bring the guiding surface close to the plane of the seat, both of which would reduce the moment of the friction or cocking stress. Any device which reduces the lift of the disk and the spring movement to the least possible amount will also reduce the eccentric spring action and its effect, and, of course, any valve design which requires or contemplates an unnecessarily large lift or compression, disadvantageously magnifies this effect.

In the well known annular type of valve the area of the disk open to the constant pressure of the steam is approximately only four-fifths of the total initial area of the disk under load in the bevel-seated form of valve having the same diameter and seat circumference. Therefore, the use of the familiar annular flat-seated valve is the logical way to reduce to a minimum all the difficulties of spring making, especially where the space available for the spring is absolutely limited by the overall dimensions permitted by locomotive builders and boilermakers; for the spring need thus be of diameter and strength to carry only four-fifths of the load necessary in the lip type of valve, the vertical lift and spring compression require to be only 0.7 as much, or for the same lift will give one and a half times as much discharge area.

No preliminary lift is required to relieve the overlap of an adjusting ring, for the work of giving to the disk its sudden pop lift is performed by an auxiliary steam discharge bypassed through the central passages. This bypassed or auxiliary discharge adds its volume to the main discharge capacity and leaves an absolutely unrestricted and unthrottled free escape for the main flow of the released steam directly to the open air without any tortuous expansion chamber or deflecting ring. The outlet is across a flat seat which not only utilizes the full vertical lift, but gives a discharge opening of cylindrical form with efficient rounded edges, and has the further advantage of being impossible to jam or stick and is easily refaced by rubbing on a face plate instead of grinding to a bevel; and as the disk can be made entirely without the ever cocking and sticking guides the efficiency of the spring can be thus aided and utilized to the greatest possible degree.

Nearly every engineer of education and experience would be qualified and ready to suggest at least one apparently simple and more or less obvious improvement in the design of safety valves or springs, but nearly every such possible detail will be found to be already old. Almost every conceivable design or modification has been the subject of a patent, and most of these have been thoroughly tried with much expense and enthusiasm before being condemned and discarded. The various subterfuges of double or eccentric springs, one more flexible than the other, spiral springs of increasing diameter whose first movement in compression is rapid until the smaller and stiffer coils are brought into action; springs suspended in all sorts of universal bearings, and every method of end bearing and fitting have all been tried and abandoned by almost every maker and user of safety valves, but are periodically redesigned or discovered by some new designer or foreman and brought forward for consideration again and again. Before any such expedients are advocated a study of the file of long-expired patents would be enlightening and interesting.

E. A. May,

of the American Radiator Company, of Chicago, discussed the safety valve as related to low-pressure, house-heating boilers.

Whether a safety valve should be called upon to exhaust all the steam generated by the boiler at its maximum capacity or whether it should care only for the excess over and above a predetermined point would appear to offer opportunity for profitable discussion, and until this point be established there can be no standard for general practice which can safely be used by all manufacturers of low-pressure boilers.

Rarely, if ever, has a safety valve on a low-pressure boiler been called upon to exhaust all the steam generated when running under its full steam-generating capacity. In the majority of heating plants the full amount of radiation is almost always in service condensing a large percentage of the steam generated, and even when the radiation is all cut out there is still circulation through the piping.

Practically every heating boiler has its damper regulator which when properly set checks combustion when a pressure of about two pounds is reached, so that maximum capacity is improbable.

Chimney conditions in the majority of heating plants are such that it would be almost impossible to drive the boiler to its maximum steam-generating capacity.

In practically all house installations at least two of these conditions exist, and in a majority all three are present, so that to select a valve large enough to exhaust all the steam which might be generated by the boiler under ideal conditions, would mean a valve out of all proportion to actual requirements.

As far as the experience of the writer goes it would seem apparent that with the present improved types of cast-iron boiler, the basing factors would be practically as follows:

First: Rate of combustion, eight pounds normally, or a maximum of twelve pounds.

Second: Calorific value, maximum nine pounds.

Third: Operating pressure of valve, fifteen pounds.

It was the speaker's opinion that if valve manufacturers would indicate in addition to the size of the valve the capacity at its different adjustments for exhaust steam it would help conditions materially, not only from the standpoint of the boiler manufacturer, but for those whose duty it is to inspect the safety valve and it would farther materially aid in the matter of legislation.

It is undoubtedly true that valves can be designed and sold on their exhaust capacity without regard to their specific size; that is owing to the variation in design one valve might have a larger diameter with lesser lift than the other, while their capacity for exhaust would be identical.

If, however, the law specifies that for a certain evaporative power, at rating, of boiler a certain exhaust capacity should be maintained in the valve, each manufacturer could then determine for himself the proper valve to use.

The speaker wished to correct a possible wrong impression left by a remark of Mr. Darling. The committee appointed by the Franklin Institute to formulate a rule adopted its own unit and prepared a formula for safety valves, the results of which were exactly similar to the French rule, so that while they may not have known the factors on which the French rules were formulated, their own rules, formulated from their own data, brought it back exactly to the same result.

H. O. Pond,

engineer and superintendent of piping for Westinghouse, Church, Kerr & Co., said, in part, that the engineer about to design a boiler installation finds himself confronted by an array of rules, covering the application of safety valves, no two of which will give the same result, and the correctness of any of which may be questioned. In the past this has not been as serious a menace to life and property as it has become recently. For a number of years past the tendency has been to force boilers farther and farther beyond the standard ratings, and to get the maximum possible capacity out of a boiler installation; so that valves which may have been of the right size for boilers operating at low ratings undoubtedly would not be correctly proportioned for boilers forced to capacities as high as 200 per cent. of their rating.

The use of the superheater has also introduced an additional factor which must be considered when deciding upon a safety-valve installation.

The absolute absence of reliable data relative to safety-valve operation and the proportioning of valves for a given service was brought very forcibly to his attention something more than a year ago in connection with the design of some special boilers of large capacity equipped with superheaters. When asked for data relative to capacities of their valves none of the manufacturers was able to furnish any definite information.

No two manufacturers use just the same lift for valves of the same "catalog" size, nor are the sizes of seat, muffle ring and ports the same. These points must necessarily affect the discharge through the valve and they are not properly considered in the present rules governing safety-valve practice.

He agreed with Mr. Ashton that the lift of the valve is not the essential thing; the thing to be determined is how much steam any given valve will discharge under particular conditions. "That particular piece of information is one that none of the manufacturers up to tonight has been willing to give us, because they have not made the tests. There are some other tests being conducted and some being prepared at the present time which will give us more definite data on which we can base the proportioning of the safety valve."

F. L. Pryor,

professor of experimental engineering at Stevens Institute, has submitted the following since the meeting:

The information that the writer secured in some tests which he made some time ago in conjunction with Professor Jacobus to obtain the blowing-off pressures of safety valves, when tested with water and when tested with steam, may be of interest.

A standard 4-inch pop safety valve set for 125 pounds was mounted on a 4-inch pipe and so connected that either steam or water under pressure could be admitted to the valve.

In all the tests the pressure required to open the valves was determined by subjecting it alternately to steam and water pressure, the set of the valve being the same for the steam and for the water in each pair of tests. The water was at a temperature of 100 degrees Fahrenheit.

One set of tests was made over a period of fifteen days, the test of one day being with steam and the following day with water, and so on until the series was completed. The lapse of time between tests was allowed to insure that the valve had obtained its normal condition of temperature, etc. In a second series of tests the valve was tested at three different settings on the same day, viz., 104, 131 and 159 pounds, the spring and valve being in each case cooled in cold water before taking the measurement for the water-pressure test.

The third series of tests was made with the valve at a number of different settings from 105 to 165 pounds, one measurement being made directly after the other, no precaution being taken to insure that the valve had returned to its normal temperature before the next test, except that before operating with water pressure a considerable amount of water was flushed through the valve.

The results obtained in all the tests were in practical agreement and indicated that the blowing-off pressure with steam and with water did not differ to any great extent, although the pressure to blow off with water was higher than with steam.

In the case when the valve was allowed to cool for twenty-four hours the water pressure required to open it was about 3½ pounds higher than the steam pressure.

In the tests where the valve was cooled thoroughly with water the pressure with water was about 3 pounds higher than the steam.

In the rapid-change test the water pressure amounted to about 2.6 pounds more than the steam pressure.

In all tests the steam and water pressure recorded was that at which the valve was in full operation. In the case of the steam-pressure test there were two testing points below full-open pressure, which also have been noted: When the valve began to leak, which occurred about 2 pounds below the final blowing-off pressure, and with the rate of flow suddenly increased, which was about 1 pound below maximum.

Prof. Edward F. Miller,

of the Massachusetts Institute of Technology, said that while the weight of steam to be discharged through a locomotive safety valve need be only a small proportion of the steam generated by the boiler, as Mr. Whyte says, in the case of stationary boilers the safety valves must be able to take care of the entire capacity of the boiler.

The sudden closing of the emergency stop valve on an engine or a turbine, by instantly stopping the demand for steam, compels the safety valves to discharge, for a time at least, as much steam as the boilers were generating at the instant that the valve closed. He had seen plants where, on account of insufficient safety-valve discharge, the pressure went up 15 pounds above the blowing pressure of the safety valves. He believed that the correct way to figure a safety valve was to make the discharge area of the valve or valves sufficient to handle all of the steam that the boiler can make at its maximum rate of coal consumption. This amounts to making the size of the safety valve depend upon the grate area, the weight of coal burned per square foot of grate per hour and the evaporation per pound of coal burned.

The weight of steam flowing through an orifice with a slightly rounded entrance may be figured quite accurately by Napier's formula (sometimes called Rankine's formula), the accuracy of which for commercially dry steam has been shown by tests made under pressure varying from 30 to 150 pounds.

The discharge per second through an orifice with a sharp edge at the entrance,

such as would be the case in a safety valve, has been found from actual tests on valves to be 0.95 of the amount figured by the Napier formula.

The opening needed in a safety valve may be figured as follows:

G = Grate area,
R = Rate of coal consumption per square foot of grate per hour,
9 = Probable evaporation per pound of coal under actual conditions,

$\frac{G \times R \times 9}{3600}$ = Weight of steam made per second.

Equate this to Napier's formula and solve for A:

$$\frac{G \times R \times 9}{3600} = 0.95 \frac{A \times P}{70};$$

$$A = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95}.$$

The area of the opening through a safety valve is equal to the inner circumference of the seat times the effective lift. For a valve with a seat at an angle the effective lift is equal to the lift multiplied by the cosine of the angle which the seat makes with a horizontal.

For a 45-degree angle the effective lift is 0.707 × lift. Calling D the inner diameter of the valve, the opening is

$$\pi \times D \times lift \times 0.707.$$

Substituting this for A:

$$\pi D \times lift \times 0.707 = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95}.$$

If the lift of the valve is $\frac{1}{10}$ of an inch,

$$D = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95 \times \pi \times 0.707 \times 0.1} = \frac{G\,R}{P \times 1.206}.$$

If the lift is 0.05 instead of 0.10, the valve diameter D is doubled. Doubling the pressure will make the same valve with the same lift taking care of double the weight of steam. Illustration:

Grate area . . . = 25,
Coal consumption = 18 pounds p'r square foot-hour,
Pressure . . . . = 120 pounds absolute,

$$D = \frac{25 \times 18}{120 \times 1.206} = 3.1;$$

Pressure . . . . = 150 pounds absolute,
Grate area . . . = 50 square feet,
Coal consumption = 25 pounds p'r square foot-hour,

$$\frac{50 \times 25}{150 \times 1.206} = D = 6.9 \text{ inches}$$

A valve as large as this would be replaced by two of equivalent capacity, and two valves of 3.45 inches diameter would give the same discharge with the same lift.

F. J. Cole,

consulting engineer for the American Locomotive Company, submitted a paper read by Mr. Pomeroy, quoting from a letter written by a prominent locomotive builder abroad to the effect that when the Ramsbottom duplex safety valves were introduced into the London & North Western railway, in 1858, they were made 3 inches in diameter at the seat each, and that size has been perpetuated notwithstanding the fact that boilers have nearly doubled in capacity and the pressures have increased 50 per cent. On the other hand, they have constructed boilers of a capacity of no more than that with which the two 3-inch valves were used, with two seats of duplex valves of 4½ inches diameter.

While it is desirable that definite rules should govern this matter, it is quite evident that peculiar conditions governing the draft on locomotives, the same necessity does not exist for safety-valve regulation as in the case of marine or stationary boilers, the action of the exhaust automatically taking care in a large measure of the generation of steam.

Locomotive boilers are carefully constructed with a factor of safety ranging from 4 to 5, they have an ample margin of strength and there is no cause for alarm even if the pressure does go temporarily 25 pounds above the normal blowing-off point.

With steam at 200 pounds pressure the temperature is about 387 degrees Fahrenheit; at 320 pounds the temperature is about 395½ degrees, or 8½ degrees higher. If the pressure temporarily goes 20 pounds above the normal, it means that the entire mass of water has been heated 8½ degrees higher than before, and it is altogether probable that with this increase in pressure and temperature most all of the radiant heat in the firebox has been absorbed.

The writer was in favor of a thorough investigation of the subject, looking toward the formulation of definite and authoritative rules for the application of safety valves to locomotives, and invited attention to the following suggestions to be considered in their preparation:

First, diameter, number and kind of safety valves to be based on their capacity for discharging pounds of steam per second at different pressures.

Second, the maximum amount of steam which a safety valve may be required to discharge when the throttle has been suddenly closed, after the fires had been urged to be based on the square feet of equated heat surface, so that the relative values for evaporation for various kinds of heating surface, where all firebox water tubes for supporting arch brick, long and short boiler tubes between the limits of 10 and 21 feet length, and valves for different spacing of boiler tubes will be taken into consideration; or what would be simpler, some approximation of average value of heating surface, corrected to account for difference in length and spacing of tubes, the firebox heating surface in this case to be considered as a certain percentage of the whole for all sizes of locomotives.

Dr. Charles E. Lucke,

of Columbia University, had one idea to offer which he thought was not of very great value. It had occurred to him in connection with some work, not of the boiler sort nor directly of the safety-valve sort, that there is another element in this safety-valve question which, while it may be of minor importance, ought to be considered, and that is the time element. He had studied to a considerable degree rapidly rising and rapidly falling pressures, and believed as a result of these experiments, which have extended over many years, that it is possible in a chamber under pressure for a sudden increase in pressure to occur and go far beyond what any safety valve may be set for, even momentarily, and it may seem that because this excess is only momentary and measured in fractions of seconds it is of no consequence, but it seemed to him that, by reason of its suddenness, it is of far more consequence.

A suddenly applied load cannot be resisted by the same metal under stress as well as a steady load, and if by any remote series of circumstances the pressure in the boiler should suddenly rise, then the time element will enter. He did not say that it is possible for it to do so, but it may, and consideration of the subject may reveal more chances for this to occur than have been apparent in the past. If the pressure does suddenly rise it will go higher than the safety valve is set for before the valve opens, and will stress the entire structure. Whether this is of any consequence in practical safety-valve work he did not know, but if it is the subject may be studied experimentally.

President Jesse M. Smith

suggested that there is another point along the same line as Dr. Lucke's thought, and that is the danger of having the safety valves too large, particularly if of the pop-valve type. If a boiler is stored with water at a temperature corresponding to 150 pounds pressure, and that pressure is suddenly relieved, what happens to the boiler? That is what makes boilers strain.

Those who have had to do with the investigation of boiler explosions, and particularly when these questions come into court, will realize the necessity of having some rules that are based upon reason instead of rules that have existed for years without any rational basis.

GARLAND P. ROBINSON,

State inspector of locomotives for the Public Service Commission of New York, said the problem in locomotive work appears to be what proportion of the maximum evaporative capacity of the boiler must be provided for. Present practice seems to show that it is necessary to provide for about 50 per cent. of the maximum evaporation.

The commission with which he is connected has collected reliable data on about 7500 locomotive boilers. During the past week he had calculated the valve capacity of 1000 of these boilers for the purpose of finding the average practice of safety-valve equipment. The greatest variations have been noted; for instance, boilers using 180 pounds pressure with valves of 1/16-inch lift have two 3-inch valves to take care of an evaporation from 1750 to 3350 square feet of heating surface. Again he found two 2½-inch valves used to take care of from 900 to 1900 square feet of heating surface. These cases represent whole classes and not individual boilers. Therefore, it would appear that no rule has been followed to determine the size of valve required.

In his opinion a formula based on the heating surface and providing for 50 per cent. of the maximum evaporation of the boiler will give satisfactory results for locomotives in freight and passenger service.

If the angle of the valve seat is 45 degrees we have

$$A = \pi D \times l \times 0.707,$$

where

A = Effective area opening of the valve,

D = Diameter of valve,

l = Lift of the valve,

0.707 = Cosine of 45 degrees.

Combining this with Napier's formula,

$$A = \frac{P \times 3600}{W \times 70},$$

the flow of steam per hour =

$$116 \times l \times D \times P.$$

Also,

Heat surface × evaporation per square foot of heating surface per hour = evaporation of boiler.

Combining we have:

$$\text{Heating surface} \times E = 116 \times l \times D \times P,$$

or

$$D = 0.05 \frac{H S}{l \times P},$$

where E = 7 pounds, or 50 per cent. of the maximum evaporation per square foot of heating surface per hour.

He had checked 1000 boilers and found the constant to be 0.0441 for present practice. Included in the 1000 boilers, however, are a number which are evidently under safety-valved, as the constant in their case is only 0.024. Eliminating this class of boiler, the constant for average practice is about 0.05, as given in the formula. He believes valves calculated by this formula will be of satisfactory capacity for road engines; also, if valves for freight engines are calculated by the formula with the constant 0.035 instead of 0.05, they will be of sufficient capacity.

WILLIAM BOEHM,

of the Fidelity and Casualty Company, was particularly interested in the statement of Dr. Lucke regarding the element of time. He did not know of any case of boiler explosion due to insufficient safety-valve area. The trouble about a boiler explosion is that after it occurs it is almost impossible to determine the cause; there is not enough of the boiler left. If a safety valve is too large it may, of course, relieve suddenly too great an amount of steam and in so doing cause a water hammer, and that water hammer may cause a violent explosion of the boiler. He believed that the correct method of proportioning safety valves was to determine the quantity of steam to be handled, rather than to take the heating surface as a basis.

PRESIDENT SMITH

said that the possibility of the valve being too large has entered into the question in France. He did not know what the law is now, but several years ago the maximum size of the valve was limited as well as the minimum size.

H. C. MCCARTY

Reference has been made to the difficulties developing out of too large a safety valve, and too large a safety valve must be construed, he believed from experience, as one with too great a lift. Several of the speakers had referred to hammer blows. Hammer blows are the result of extraordinary lift, resulting not only in the destruction of the valve, but in damage to the boiler.

No suggestion has come to the notice of his company (the Coale Muffler and Safety Valve Company) in the years of their experience in producing the valves which they do, that any advantage would be gained in locomotive service by increasing the lift above that usually followed by the majority of the manufacturers; in fact, they had found the contrary to be the case. It is true that the lifting of water and the destruction of the valve have been clearly demonstrated in practice. Beyond this he believed that there is a more vital and more serious element of difficulty. Any disturbance of the water level, especially in the modern locomotive boiler, is a serious problem confronting every man who is responsible for locomotive maintenance. We aim to work the driest steam possible through the chests and cylinders and through the throttle, which is located at the highest point possible. His observation had been that any agitation of the water will lift water through the valve or cause it to pass through the throttle, if the throttle is open at the time.

The location of valves seems to be overlooked in many instances by designers. One speaker has referred to the placing of the safety valve on the dry pipe. Their experience indicates that the connection between the valve and the boiler should be at a point as high as the clearance will permit, and with the shortest possible intermediate connection.

M. W. SEWALL,

of the Babcock & Wilcox Company, suggested as the two items that need to be considered: How much steam can the boiler make? How much steam will your safety valve deliver? If these two items are considered, the diameter and the lift, the approach to the safety valve and the discharge from the safety valve can all be readily taken care of, and when they are settled one maker can make a big-diameter barrel and small lift and another a small-diameter barrel and big lift, just to suit their own conditions or their own tastes, and when they come to place them on the market the one that comes out ahead will be the best for its own manufacturer.

GEORGE I. ROCKWOOD

thought that it was obligatory upon Dr. Lucke, now that he had "thrown that scare into us," to state what his experiments were that lead him to believe the sudden generation of pressure in boilers possible. Mr. Darling's demonstration that the lifts of valves vary up to 300 per cent., making an enormous difference in the steam discharged, ought to interest the boiler-insurance companies, and he did not see why these companies had not conspired together in some such way as do the ordinary fire underwriters—have a laboratory of their own and find out the conditions which affect the design of safety valves and devices in general that are used about the boiler plant, and then lay the law down to the several manufacturers and deliberately "Approve" their devices (and spell the approve with a capital A), and not write insurance where those devices are not used. That is the club that is most successful in producing splendid apparatus for fire protection, and he thought it would be equally effective as applied to steam-boiler protection. If Mr. Boehm, of the Fidelity and Casualty Company, never knew of an explosion of a boiler being due to an in-

efficient safety valve, then the speaker did not know what the agitation of the evening was about, but doubtless that is a view which is subject to modification.

A. A. Cary

agreed with Mr. Carhart that the small-lift motion spring is certainly the safest. He called attention to his discussion in the December, 1901, meeting of the society, of the subject of springs, and said that the diameter of the spring should be to the diameter of the wire about as 7 to 1, and may possibly be reduced as 5 to 1, but that is not good practice for pop safety-valve springs. He saw no good reasons for using wire of square section and thought the round section safer. An extension spring would be safer than a compression spring.

Care should be used in safety valves for use with superheated steam to see that they are not subjected to temperatures above 450 degrees. In the Cary process, invented by his father, the spring was subjected to a temperature just above that point (the point of recalescence), and it would hold the shape to which it was bent. All of the "set" must also be taken out of the spring before it is put into use.

A. D. Risteen,

of the Hartford Steam Boiler Inspection and Insurance Company, indorsed Mr. Rockwood's suggestion of an experimental laboratory for the underwriters of boiler risks, and pledged his influence to that end; but when Mr. Rockwood suggested that they try to lay down the law to the manufacturers and owners of boilers, he thought he had suggested a task from which the insurance companies might shrink.

F. L. DuBosque,

of the Pennsylvania Railroad Company, congratulated the company upon the fact that if they had not learned anything else that evening they had learned the reason for the adoption in the United States laws of a formula that has caused marine engineers more trouble than anything else for the last few years. From the fact that one of the speakers of the evening had laid so much stress upon this formula, and from the fact also that it was exhibited among the formulas thrown upon the screen, it may be looked upon with confidence. He hoped no one would be deceived by it; it was the poorest formula ever established.

He had had a little experience with it a short time ago. The formula as incorporated in the United States laws leaves in the hands of the inspector the decision as to how much coal shall be burned per square foot of grate. In determining the size of the safety valve he knew from actual experience that a particular boiler could not burn more than 16 pounds of coal per square foot of grate area. He figured accordingly that it required a 3¾-inch safety valve. They sent their plans forward to the inspector and he said: "You are wrong; this boiler will burn 20 pounds of coal per square foot of grate area and it requires a 4.23-inch safety valve, and the nearest size is 4½; a safety valve fully 50 per cent. larger than is actually required to be used on the boiler."

L. D. Lovekin,

the author of the formula, assured Mr. DuBosque that he had had quite a little to do with boilers in the design of boilers for different steamships in the United States service and had interviewed hundreds of engineers, all of whom, with the exception of Mr. DuBosque, had complimented him upon that formula. Everybody knows that any boiler safety-valved on 1 square inch of valve for 3 square feet of grade for a Scotch boiler and 1 square inch of safety valve for 6 square feet of grate area for a water-tube boiler is both ridiculous and absurd. Whenever he had said a boiler would evaporate so much water and submitted the design, he had never had an inspector return the boiler for additional safety valves. The United States Navy authorities, with all their experience, together with several prominent authorities abroad, have agreed upon a lift of ⅛ of the diameter of the valve.

In the present discussion there seems to be a misconception as to what constitutes high lifts. He did not think there was a safety-valve manufacturer in the room who cared to see a safety valve lift 1 inch, no matter how large it is. His rule was based on the proportion which the lift bears to the diameter and it falls on ⅛ of an inch for a 4-inch valve, and, therefore, the largest valve approved for naval work, 4½ inches, would not have an excessive lift under that formula.

Dr. Lucke,

in response to Mr. Rockwood's request, said that he had never seen the pressure rise in a steam boiler in the way to which he had referred, and did not believe that it could rise in that manner, but that if it does so rise the effects described will be those so produced; he had seen it arise from other causes.

Mr. Carhart

thought that there is one way in which safety valves should not be rated and that is by the area of the disk or of the inlet connection, for in every case the outlet discharge capacity is proportional to the circumference of the valve seat and the circumference will, of course, increase in proportion to the diameter, while the inlet and disk areas will increase in proportion to the square of the diameter. The lift may properly be assumed to be uniform in all sizes of valves such as were under consideration, for this is the actual performance in practice. If there is any measurable difference in special cases it will generally be found that the larger valves lift less than the smaller ones. This is as it should be from the practical point of view, for prompt and quiet action, durability of the valve and safety of the boiler. The smaller valves have less weight of moving parts, less momentum, less load, springs of more tractable proportions and may safely lift higher.

Valves should not be rated in discharge area alone. The discharge area would be different for every pressure and would be dependent upon the care taken in maintaining the uniformity of commercial springs. It would be at best a theoretical amount arrived at by a formula which might be amended by any designer or salesman to suit the exigencies of every contract, price or specification of capacity. This would introduce hopeless confusion in odd sizes and leave the engineer at the mercy of the representations or misrepresentations of selling arguments. The standard sizes, familiar in practice to all engineers, now denote the size of the inlet-pipe connection which must be provided in the boiler. If different designs of valve have different apparent or claimed efficiencies, allowance can be made for this in the judgment of the engineer. The actual lift or discharge areas of valves should be determined and reported upon after impartial tests, conducted by competent and disinterested engineers, under conditions of scientific accuracy and fair precautions, where each valve is intelligently regulated to work within its normal intended limits.

President Smith

In rating a valve by its diameter, do you use the small diameter of the inside or the larger diameter on the outside of the seat?

Mr. Carhart

We always use the small diameter of the side open to the steam pressure when the valve is closed.

Philip G. Darling

Mr. May said that the Franklin Institute committee came to the adoption of their rule by a method of reasoning absolutely independent of the French people, who formulated the rule. That is so, but when they made their rule they obtained what they thought was right theoretically, and then they increased it by 50 per cent., and after that they multiplied it by eight as a factor of safety. It seems to me that the remarkable coincidence of the two rules loses some of its force when you take that into consideration.

NATHAN PAYNE

pointed out that the only profound issue in this discussion is that there has been no standard measurement of any safety valves probably to date, and whether we take a high-lift valve or a low-lift valve what we should do is to get some formula therefor measuring what one is offering when he offers a "4-inch" valve, what it will do and whether it is good for a 100-horsepower boiler or a 200-horsepower boiler.

The Shunted Ammeter

BY CECIL P. POOLE

The simple series-connected ammeter, the winding of which is merely inserted in one leg of a circuit and takes the full current, is readily understood by the average engineer. The current flows through the winding just as steam or water flows through a valve or other device inserted in a pipe. The shunted ammeter, however, is not so readily understood by beginners in electrical work, as indicated by numerous letters of inquiry received by the editorial department of this journal.

Fig. 1 is an elementary diagram of the connections of a shunted ammeter and its shunt. The latter consists of a conductor *S* of accurately known resistance, usually fastened to two relatively massive terminal blocks; the circuit wire in which the current is to be measured is cut and the two ends attached to the terminal blocks of the shunt; consequently the shunt forms a part of the circuit carrying the current to be measured. Also attached to the terminal blocks are two small flexible conductors, the other ends of which are connected to the terminals of the instrument; these conductors are twisted together, forming the flexible cord used with portable incandescent lamps, voltmeters, etc., although the diagram shows widely separated leads from the shunt to the instrument.

The instrument, though called an ammeter, is really a voltmeter of small range, usually around 50 millivolts; that is to say, an electromotive of 50 millivolts or fifty one-thousandths (one-twentieth) of a volt applied to its terminals will carry the needle to the extreme limit of the scale. The scale of the instrument, however, is marked in amperes instead of volts, the shunt being proportioned to suit the desired range.

Suppose, for example, that the instrument and shunt are designed for a "full scale" reading of 50 amperes. This means that when 50 amperes flow in the main circuit, the voltage at the terminals of the instrument must be 50 millivolts, in order that the needle may be deflected to the end of its scale. Ignoring the resistance of the "ammeter," which is relatively high in most cases, the resistance of the shunt conductor *S* must be one-thousandth of an ohm in order to show a difference of potential of 50 millivolts at its terminals when 50 amperes pass through it, because

$$Volts \div Ohms = Amperes,$$

and consequently

$$Amperes \times Ohms = Volts.$$

In the case mentioned, therefore, when 50 amperes pass through the circuit, there will be 50 millivolts at the instrument terminals and the needle will be carried to the end of the scale; this point is marked 50 amperes, instead of the 50 millivolts which the instrument is really measuring. When 25 amperes flow through the shunt, the voltage at its terminals will be

$$25 \times 0.001 = 0.025$$

volt or 25 millivolts, and the needle will point to "25" on the scale, and so on. In this case the scale would be marked exactly as it would be to indicate millivolts, because the number of amperes in the main circuit would always be exactly

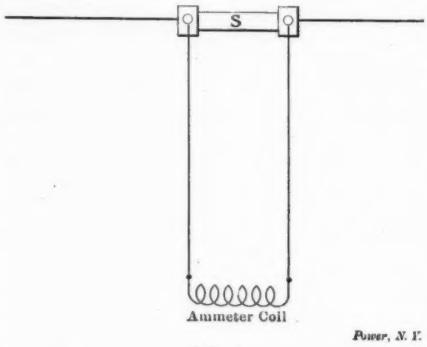


FIG. 1

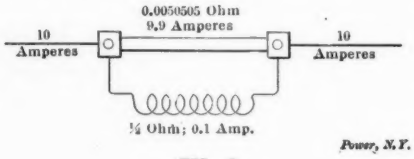


FIG. 2

the same as the number of millivolts at the terminals of the instrument.

No matter what the range of the instrument in amperes may be, however, the voltage at its terminals will be 50 millivolts when the full current is passing. The same instrument may be used, therefore, for any current range by changing the shunt and the scale on the instrument. For example, suppose the maximum current "capacity" were 1000 amperes. Then the resistance of the shunt would have to be 0.00005 ohm in order that Amperes × Ohms should equal 0.050 volt at "full scale" current in the main circuit. With 1000 amperes flowing, therefore, the potential at the terminals would be $1000 \times 0.00005 = 0.050$ volt or 50 millivolts, and the needle would be deflected to the end of the scale, which would be marked "1000," instead of 50 as in the first case; with 500 amperes, the potential would be $500 \times 0.00005 = 0.025$ volt or 25 millivolts, and the needle would stand at the point which was marked "25" in the previous case, this point being marked "500" on the scale now used. So on, through the whole list of "ammeter" capacities. The relation between the current in the main circuit and the deflection of the needle is determined entirely by the resistance of the shunt conductor.

The resistance of a millivoltmeter requiring 50 millivolts for full scale deflection is from ½ to 1 ohm, according to the design of the instrument. When used to indicate currents of 100 amperes or over, the resistance of the instrument is so high with relation to the shunt that it is ignored. For smaller ranges, however, the resistance of the instrument is considered by the more careful manufacturers. For example, if the full scale reading is 10 amperes and the instrument requires 50 millivolts for full scale deflection and is of ½ ohm resistance, the resistance of the shunt conductor should be 0.0050505 ohm; the joint resistance of the shunt and the instrument winding would then be 0.005 ohm, and with 10 amperes flowing in the main circuit the voltage at the terminals of the shunt and the instrument would be 0.050 volt, or 50 millivolts, as required. Of the total current, 9.9 amperes would flow through the shunt and 0.1 ampere through the instrument. This set of conditions is represented diagrammatically in Fig. 2. If the resistance of the instrument were ignored in this case and the shunt were made of 0.005 ohm resistance, the joint resistance of the two would be 0.00495 ohm and in order to get a full scale deflection the current in the main circuit would have to be 10.1 amperes instead of 10. This is an error of only 1 per cent., and would not be very serious. It is too large, however, to satisfy a maker who strives for as high a degree of accuracy as is commercially practical, and such a maker would probably make the shunt of 0.00505 ohm resistance. Then the joint resistance of the instrument and the shunt would be 0.0049995 ohm (assuming perfect connections and other conditions) instead of 0.005, and the error would be insignificant.

The resistance of the flexible cords leading from the shunt to the instrument is so low that the error caused by it cannot be measured by ordinary instruments. In many shunted ammeters of low range the shunt is mounted in the case which contains the meter mechanism and winding; separate connections are therefore unnecessary. When the shunt is separate, however, as indicated by the simple diagrams herewith, it is necessary that the flexible cord connecting the instrument to the shunt should be very firmly secured at both ends; any looseness of connections will cause the instrument to indicate falsely by reason of the increased resistance of the branch circuit passing through the instrument, the error being of the nature of indicating a smaller current than is really flowing in the main circuit.

Some Useful Lessons of Limewater

How Coal Burning Makes Carbonic-acid Gas; Why Fire Must Be Lighted before It Will Burn; What Causes Fire Heat; Expansion and Contraction

BY CHARLES S. PALMER

Coal Burning Makes Carbonic-acid Gas

Here is a clean, common fruit jar. Pour into it some filtered limewater and shake it up. There is no especial change, for the air in the inside of the jar is much the same as that on the outside of the jar; although if you let the limewater stand in the jar for a few minutes, you will see that its surface becomes covered with that thin white skin, or "pellicle," of plain insoluble carbonate of calcium. You can observe this better if you pour out several tablespoonfuls of the limewater into a common glass tumbler and let it stand on some dark surface, say a piece of black paper. Soon the thin white skin of plain carbonate of calcium will form over the surface, and this will remind you that the air about us carries some of this carbonic-acid gas, about one part by volume in three or four thousand of the air. When considerable of the plain carbonate of calcium has formed by exposing the filtered limewater to the air, just clear it all up with a drop of hydrochloric or nitric acid; if you look carefully, you may see a little bubbling, as though you were treating some bits of marble with the strong acid.

Now, rinse out the jar, and hold down into it a burning common wood splinter. In a few moments remove the burning splinter and pour into the jar a few tablespoonfuls of filtered limewater. Clap over the mouth of the jar a piece of common cardboard for a cover, and shake it well. You will note the same white, milky precipitate of plain carbonate, and you will be ready to study it with new questions and answers.

Now repeat the experiment of the last lesson, where you tried to find out the parts of the air, and where you used sulphur or phosphorus; only in this case use shavings, paper and the like. You will find that the experiment will work, but it will be slower than in the case where you used the phosphorus, or the sulphur, or the match ends. The products of burning the shavings or the paper will not absorb nearly as readily as the burnt products from the phosphorus or the sulphur. Indeed, although there is the same loss of bubbles of air, at the first, from the same expansion by heating the air in the jar, and although there is about the same amount of oxygen burnt out of the air, yet the absorption by the water in the jar in the case of the paper or shavings is not nearly as great as in the case of the sulphur or phosphorus. But if you replace the plain water in the wash dish with a solution of filtered limewater, then you will get about the same results as you got in the case of burning sulphur or phosphorus over plain water. The reason is, of course, that the acid-like stuff from the burning of sulphur or phosphorus is easily soluble in plain water; and the stuff from the burning of the shavings or paper, while not soluble in plain water, is nevertheless easily soluble in limewater. Try all this and you will get the facts. Now for the explanation:

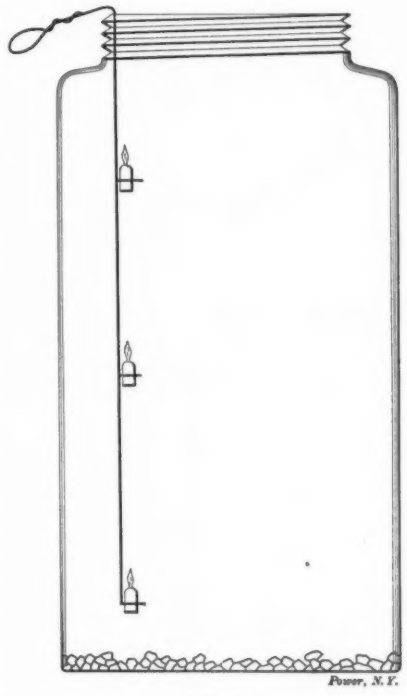


FIG. I

The Union of Things Unlike

We have seen that in general unlike things unite with each other. Thus acids unite with bases and bases unite with acids; but bases do not unite with bases, nor acids with acids. It is much like the marriage of male with female and of female with male, but with the comparative indifference of male for male and of female for female. It is this principle of the *union of unlike things* that guides us in chemistry. Now to go back to the experiment; you could test the limewater with litmus, and you found that it turns it blue; that is all right, for the limewater is an alkaline base. You also found that the water solution from the burning of the sulphur or the phosphorus, or the match ends, turns litmus red; and that is also all right, because the substances formed are acid-like.

But, in the case of the carbonic gas from the burning of wood, paper or coal (we call it carbonic-acid gas, although it affects litmus very feebly), we have to reason back to prove that the carbonic gas is an acid. We reason this way: Limewater is a base. Carbonic gas unites with limewater and is therefore unlike limewater; consequently, it is an acid, carbonic-acid gas. But there is also another side to this proof. That is that acids will displace acids and bases will displace bases. We find that this principle works well, for we can drive off the carbonic-acid gas which has been absorbed by the limewater, by any strong acid, such as hydrochloric acid or nitric acid. It will be well for you to make quite a quantity of this same plain carbonate, by blowing your breath (which is the burnt carbonic-acid gas from the body furnace) into some filtered limewater; let it settle, and then pour off—"decant off," the books say—the liquid from the sediment. Then take this sediment and treat it with a few drops of hydrochloric acid; the chlorine of the hydrochloric acid will displace the C-O-two (CO_2), carbonic anhydride, or carbonic-acid gas, from the plain carbonate of calcium, making calcium chloride ($CaCl_2$), C-a-C-l-two. So by reasoning backward and forward, we can prove that as this carbonic gas unites with bases like lime, and as it is displaced by acids like hydrochloric or nitric or vinegar, therefore it is an acid, carbonic-acid gas.

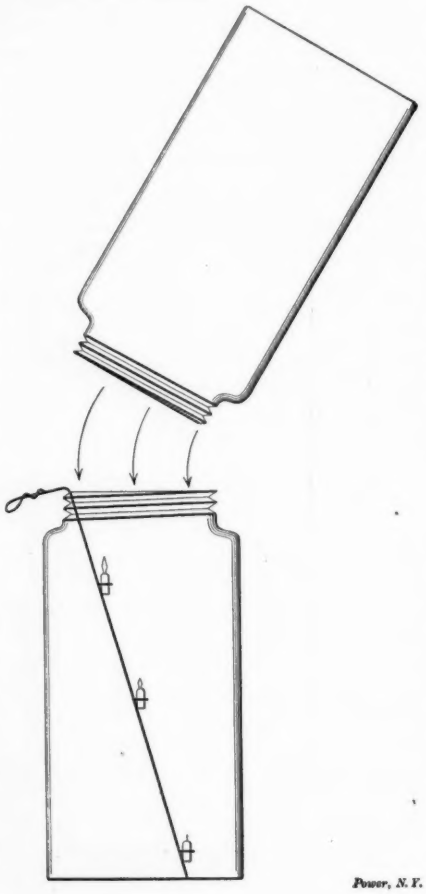
Where the Carbonic-acid Gas Hides

But we must find out still more about this colorless gas into which black coal goes on burning, and where it hides itself. Here is a tall jar, a large fruit jar will do. Pour into the bottom some powdered marble, or some common cooking soda; both are "salts" of this same carbonic acid, one with the base lime, or calcium oxide, and the other with soda proper, the oxide of the metal sodium. Now prepare several bits of candle strung on a wire, like that shown in Fig. 1. Small Christmas-tree candles, or birthday-cake candles are good for this experiment. Light them, and lower them into

the jar (one candle can be cut into several pieces). Now pour in some strong acid, like hydrochloric acid. You will see the lively foaming, or "effervescence," as the books call it. That is the giving off of the invisible carbonic-acid gas. Now this is a heavy gas; that is, heavy as compared with the air, which, of course, is and must be the standard gas, because the air always surrounds us, and we are much like human fish walking about in this invisible ocean of atmosphere. As the carbonic-acid gas comes off in the jar, being a full-fledged gas it displaces some of the air from the jar. But being a heavy gas, it displaces it from the bottom first; and so, if you are successful with your experiment, you will see the lowest candle go out, because it cannot burn in this carbonic-acid gas. Then the next higher candle will go out, and so on to the top. If you have enough marble dust, or soda, and acid, you can literally flood the candles in order from the bottom to the top.

But this is only the beginning of what you can do with this heavy gas. You treat it as though the jar were full of a light invisible liquid. Thus you can take out the candles strung on the wire, light them again, and set them in another clean and empty jar. Now take up the first jar, which is full of the invisible carbonic-acid gas, and pour it slowly (Fig. 2), for it will not pour quickly like water, into the second jar with the relighted candles. You will see them flicker and tremble as their flames are choked or drowned by the inpouring heavy gas. If you have ordinary luck, you will extinguish some of the lower candles, and you will clearly prove to yourself that this gas is a heavy gas which follows the laws of heavy liquids insofar that it displaces the lighter air. Later, when we get to the study of the very light gas, hydrogen, you will try that the other way, and you can pour it *upward* in the air, from one jar to another; and in that case you will test it by the flame, for hydrogen burns in the air.

Now there is one more test that you want to try again, if you have not done so already; for you will devise many experiments for yourself, and try your own ideas all the time. The test is to see what litmus, red and blue, will do in some strong water solution of carbonic-acid gas, like the "fizz" water or common "soda water." You will find that the litmus will probably turn red; but if you take the litmus paper out of the water and let it dry in the air, the volatile carbonic-acid gas will be driven off from the litmus by the nonvolatile red acid of the litmus, and the litmus will probably go back to blue. But it is possible that only *one* of the slips of litmus paper will go back to blue; because, if one of the slips was already red when you put it into the solution of carbonic-acid gas, and if it was colored red by some strong acid, such as sulphuric or nitric, or hydrochloric, then such a slip of red litmus paper may remain red in the strong solution of carbonic-acid gas, and may still remain red when taken out of the water; while the other slip of litmus paper, which was blue to start with, but which was turned red by the carbonic-acid gas solution, will probably turn blue again on standing in the air. This is only to show that no fixed rule can be given to the exclusion of the free use of one's brains. We must think in all things, and while the principles given may be accurate and correct, yet their use and application may require some thinking.



Power, N.Y.

FIG. 2

But we have learned that the gas from the burning of coal, wood, or paper is mostly carbonic-acid gas; and that it comes from the union of the carbon of the coal, wood or paper, with the oxygen of the air.

Why a Fire Must Be Lighted Before It Will Burn

The fact that you may have the grate of a stove or furnace well cleaned out, that you may have the fire materials laid in order, from the shavings and kindlings and the wood to the coal, that you can have all this with the draft open and the free-flowing air all about ready to seize on the fuel, and yet there is nothing doing in the way of real fire, is a matter of everyday experience. In fact it is so common that its meaning and significance may easily escape the attention which they deserve. Why does fire material have to be *kindled* before it will burn? That is the question. It must be connected with the heat given off, because when the fire is once hot, we can kindle any amount of fuel from it.

The explanation of this curious necessity for kindling any combustible, from the match that we light by the slight friction heat of a quick stroke to the gas that burns with a hot flame, or to the still harder coal, is that all matter is made up of *groups* of chemical units. The group is called a "molecule;" and the chemical unit is called an "atom." Thus, the molecule of hydrogen is written H_2, and is called H-two; that is, there are two chemical units or atoms of hydrogen in the molecule group H-two. Similarly, the gas that comes from heating coal, and which burns with a blue flame, is called carbon monoxide (carbon one oxide), CO, and read C-O; that is, there are in the molecule group one atom of carbon and one atom or chemical unit of oxygen. Similarly, in the air the oxygen is found as molecule groups of O_2, called O-two, and the nitrogen as N_2, called N-two. Some molecule groups of chemical units or atoms contain two, some three and some four, five, six, or many more of the atoms or chemical units.

What Causes the Heat of Fire

Now, the heat from a fire is caused by the atoms of the various molecule groups falling together to make new molecule groups; and yet, before the chemical units, or atoms, can fall together in the new combinations, they must be free to come together. It is a case of "off with the old love, before on with the new." So it takes quite a degree of heat to shake the atoms loose from the old molecule groups before these same atoms can be free to fall together into the new molecule groups.

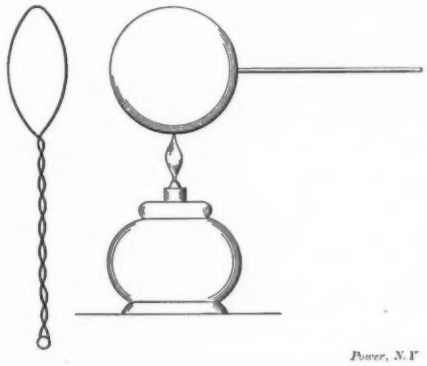
If you should ask how it is that we know that matter is made up of these molecular groups and that these molecules are themselves made up of still smaller atoms or chemical units, it would take some time to give all the proof. But you can begin to convince yourself right here that all matter has a "grained" structure. Thus, think what it means that common salt, for example, can be dissolved in water, can be passed through the pores of the finest filter paper, and can be evaporated down to dryness and recovered—all this shows that the lump of salt is made up of very small pieces which separate from each other in the solution in water, and which pass in droves through the pores of the paper and come together again; and yet in all this we have not got into the inside of the molecular groups of common salt, each of which is made up of NaCl, read N-a-C-l;

that is, each molecule of common salt consists of one atom or chemical unit of sodium (the metal back of all the soda compounds) and one atom of chlorine. But the molecule, salt, is a thing by itself, and it consists of atoms; and similarly every kind of matter consists of atoms united into molecules. The study of these unions of the atoms of each element as they make up the molecules of this and that substance is analysis. Analysis is called "qualitative" if it tells us *what* the *kind* of atom is in each substance; analysis is called "quantitative" if it tells us *how much* there is of each substance. You see that one is led to the study of the molecule and the atom from this fundamental fact that fuel ready to burn will not burn until the atoms of the molecular groups are torn asunder from the old molecules and made "free" to unite with the oxygen atoms, which must be also torn asunder from each other to burn the fuel, in making new molecules. Thus, the very fact of kindling a fire implies a difference between molecules and atoms.

Expansion and Contraction

It will be some time before we can take up very much of the proof for the molecular theory of matter and, beyond that, of the atomic theory of the molecules of matter; but you can be getting your mind in shape to handle some of these curious notions by asking yourself such simple questions as these: What happens when bodies expand with heat and contract with cold or pressure? What happens when any substance expands and contracts? All matter, in general, expands with heat and contracts with cold or pressure; what happens when matter expands? What happens when matter contracts? Whether it is a solid, a liquid, or a gas, the question is the same in kind; but you can think more clearly if you make this simple definite experiment: Take a ball of some metal, iron or brass will do, and then make a ring of metal of such size that the ball at common temperature will just pass through the ring of metal, Fig. 3. It would be better if we could afford to have some metal like gold, platinum or nickel which will not rust nor oxidize on heating; but the iron will show the principle. Now heat the ball so that it will not pass through the metal ring. What has happened to the ball of metal? If you could weigh the ball, cold and hot, you would find that there is no difference in weight, only some slight rusting; but the test has been tried with balls of gold and platinum which do not rust nor oxidize by heating in the air, and it has been found that there is no difference in weight, hot or cold. Then there is no more matter in the ball whether it is cold or hot; note that. Heat neither adds to nor takes from the weight or "mass" of a body. Now if the ball of metal weighs the same cold or hot, if there is no more matter when it has expanded, what is the expansion?

Clearly, the expansion is the separation of small parts that are too small to be seen or felt; but there must be those small parts just the same, and it must be the separation of those small parts which shows on the outside as expansion of the whole ball. Similarly, it is the approaching of these small parts that makes the ball contract. Then the ball, though solid, is made up of small parts, that must be separated from one another by some degree of space; these approaching and receding parts are the molecules, and these molecules are made up of still smaller parts, the chemical units or atoms. It will take you some time to get used to this kind of thinking; but it will pay you, for it leads not only to clearer ideas regarding the nature and structure of the kinds of matter about us, but it also leads us to some practical ways of attacking and analyzing the water that goes into your boiler, the fuel that you burn under the boiler, the ashes that you shovel away, the iron that makes up the boiler and connections, and so on to anything you want to know more about for yourself.



Power, N.Y.

FIG. 3

The molecule of lime is written CaO, and it is made up of one atom or chemical unit of the metal, calcium, and one atom or chemical unit of the burn-helper, oxygen. Water is made up of molecular groups, which are composed of the chemical units told in the short form, H_2O (H-two-O); that is, two chemical units or atoms of hydrogen and one atom or chemical unit of oxygen; and so it goes. All this exactness of chemical composition means but one thing, and that is that at the bottom of analysis there must be the atoms, little bodies which have a weight fixed for each element, and hence called the "combining weight," or "the atomic weight." The tables of the atomic weights which are found in every textbook of chemistry will begin to have a new meaning for you, for they stand for the sizing which Mother Nature has done for each of the elements. As far as we know, all the atoms of any particular element have the same combining or atomic weight, different from the atomic weight of any other element; 1 for hydrogen, 16 for oxygen, 40 for your friend calcium, 14 for nitrogen, 35.4 for chlorine, 32 for sulphur, and so on. The simple statement of these atomic weights tells a story of its own, but it all may start from that old friend, the quicklime which has got you on the run and which will not let you stop until you learn a little of the special story of calcium and of the larger novel of chemical analysis. This story must be worth learning, for it helps to make "gray matter," and it will put you on your feet a little stronger and make you more ready to hold your own in the promotion that starts from your barrel of lime.

Conservation of Natural Resources—Engineering Societies' Meeting

There will be a special meeting on March 24 under the auspices of the four national engineering societies, American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, on the general subject of "The Conservation of Natural Resources." The following program will be presented by representatives of the four societies:

"The Conservation of Water," by John R. Freeman, A. S. C. E.

"The Conservation of Natural Resources by Legislation," by Dr. Rossiter W. Raymond, A. I. M. E.

"The Waste of Our Natural Resources by Fire," by Charles Whiting Baker, A. S. M. E.

"Electricity and the Conservation of Energy," by Lewis B. Stilwell, A. I. E. E.

Spring Meeting of the A. S. M. E.

The spring meeting of the American Society of Mechanical Engineers will be held at Washington, D. C., May 4 to 7, inclusive. The local headquarters will be the New Willard hotel, rooms in which may be secured by members two weeks in advance—not later. The definite program cannot be announced yet. Among other plans it is proposed to furnish members a condensed handbook of the most interesting points in the city, with needed information, and excursions will be organized. The University Club of Washington has extended an invitation for the society to make free use of its rooms and privileges.

March 27 to April 3, inclusive, there will be a mechanical and electrical exposition in Mechanics' hall, Worcester, Mass., which promises to be one of the best exhibitions of the kind ever held in the Bay State. The electrical features will be especially notable and will include many new devices, as well as the latest types of generating machinery.

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Coal Weights

A manufacturing concern recently adopted a method of checking its coal weights and found that it was receiving considerably less coal than it was charged for, one barge load being some sixty tons short. The management refused to pay for more than was received, and the coal company brought suit to recover the full amount of its bills. Testimony was offered to the effect that it was the general custom to accept "railroad weights" in billing and settling for coal delivered, after which the attorney for the coal company announced: "Your Honor, the plaintiff rests his case;" whereupon the court immediately responded: "The plaintiff has no case."

Not a word of testimony had been offered to show that the amount delivered agreed with that for which bills had been presented, and if the current practice is anything like that which the attorney for the coal company tried to establish, it will be well for others to put some kind of a check upon their coal receipts.

Safety Valve Formulas

Attention is called to the communication from Philip G. Darling on page 511 of this issue. The formula which he criticizes appeared in our issue of March 9, and assumed that safety valves in general, whatever their diameter, are designed to lift between one-sixteenth and three-thirty-seconds of an inch.

The formula was suggested as an improvement upon that now used by the United States Board of Supervising Inspectors of Steam Vessels, which is based upon the assumption that valves lift one-thirty-second of their diameter, and which gives the result in area instead of directly in the number of inches of diameter required. The bringing out of the fact that large valves lift no more than small ones eliminates the necessity of using the diameter twice, and makes possible the simple expression proposed, in which the result is obtained in inches of diameter without the use of roots or powers or the conversion of areas into linear dimensions.

Mr. Darling's formula also expresses the results in terms of the diameter, is practically as simple and avoids any assumption in regard to the lift by making the lift itself a factor of the formula. This is safer unless the assumption that any valve will lift at least five-sixty-fourths of an inch without dangerous increase of pressure is warranted. Many of the valves which Mr. Darling has tested have not lifted this amount at the popping pressure.

It was not intended, in the editorial proposing the simplified formula, to detract from the credit due to Mr. Lovekin, the author of the formula now in use. His formula is rational, and would be correct if the assumption upon which it is based, that the lift varies in the chosen proportion to the diameter, were true. The papers and discussion at the meeting of the mechanical engineers seemed to show that the assumption was unwarranted. It was a common assumption in the engineering bodies which had given the subject the most attention, even greater proportionate lifts being assumed by responsible official boards, and Mr. Lovekin is entitled to the credit of having substituted a rational formula for the archaic and inadequate one based only upon grate surface in use at the time.

Receiver Drop

It has been aptly said that the facts evolved by practice would fulfil the predictions of theory—if the theory were right—and the facts correctly stated.

The theory must, however, be complete as well as right. One does not condemn as a scientific lie the academical demonstration of Carnot that the most efficient diagram for a heat engine to make is one in which expansion is carried to the back pressure, and compression to the initial, although few engineers would try to carry out the cycle so suggested in the real cast-iron cylinder, with its heat-absorbing properties, with compression processes which are of considerably less than one hundred per cent. efficiency, and with an investment which must be made to yield the utmost per unit of interest and overall charge.

It is also quite true, from a thermodynamic standpoint, that the greatest amount of work will be got out of a pound of steam when there is no free expansion, as in the receiver of a compound engine, i.e., when the diagram from the high-pressure cylinder ends in a point. That this is found to be not the fact when it is tried should not upset one's confidence in the academical demonstration, which is plain and incontrovertible, so far as it goes, but should set one to looking for the disturbing cause. One does not deny the universality of the law of gravitation because a penny falls faster than a feather, but mentally clears the situation of all disturbing influences, such as air resistance, before he applies the law.

What the causes and conditions are which produce results at variance with the abstract truth that free expansion results in loss we do not know. Here are a couple of facts:

Some years ago an engineer operating a pumping engine with fixed cutoff discovered that when the receiver pressure was changed there was also a change in the speed of the engine. Reducing the receiver pressure increased the speed and increasing the pressure reduced the speed.